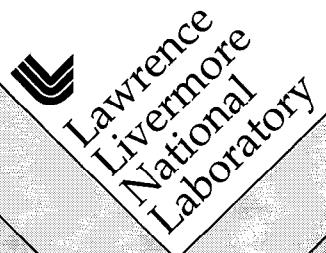


UCRL-CR-132949
B344832

Ignitability of DMSO Vapors at Elevated Temperature and Reduced Pressure

Erdem A. Ural
William Weisgerber

March 8, 1998



DISCLAIMER

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

CRC Technical Report SSR-1953/SO-47152

**IGNITABILITY OF DMSO VAPORS
AT ELEVATED TEMPERATURE AND REDUCED PRESSURE**

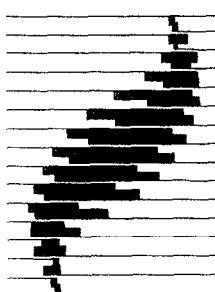
By
Erdem A. Ural and William Weisgerber

Prepared (under Purchase Order B344832) for:

**Dr. Werner Bergman
University of California
Lawrence Livermore National Laboratory
7000 East Avenue
Livermore, CA 94550**

8 March 1998

COMBUSTION RESEARCH CENTER



90 Brook Street
Holliston, MA 01746
Tel: (508) 429-3190 Fax: (508) 429-2990
e-mail: crc@world.std.com
Fenwal Safety Systems
A Division of KIDDE Technologies, Inc.

CONTENTS

Section	Page
I. Introduction	1
II. Experimental Details	4
2.1. Test Apparatus	4
2.2. Test Procedures	11
III. Determination of the Lower Flammability Limit	13
3.1. Electric Match Tests	13
3.2. Carbon Spark Tests	14
IV. Minimum Ignition Energy Under Specified Conditions	18
V. Ignition Temperature for Sandia Spark generator	26
VI. Summary of Results	29
APPENDIX A listing of the Electrical parameters	31

I

INTRODUCTION

The objective of this project is to study the lower flammability limit temperature of the Dimethyl Sulfoxide (DMSO) vapors, to investigate how the ignition energy varies as a function of the temperature, and also to determine the temperature at which the Sandia Electrostatic Discharge Generator will ignite the DMSO vapors.

Since DMSO has relatively low vapor pressure, flammable vapor concentrations are achieved only at elevated temperature or reduced pressure. At a specified temperature and pressure, the maximum possible DMSO vapor concentration is determined by the DMSO vapor - liquid equilibrium. Assuming that vapor-liquid equilibrium exists and that there are no suspended DMSO droplets, the vapor-air mixture will be below the lower flammability limit at low temperatures. Therefore, at low temperatures, the vapors can not be ignited even with strong ignition source. As the liquid temperature increases the vapor concentration also increases, and mixtures can be ignited with weaker and weaker sparks. As schematically shown in Figure 1, the minimum ignition energy (the smallest amount of spark energy required to ignite the worst case DMSO vapor - air mixture at a given temperature) first decreases then increases as the temperature goes up. The minimum point of this curve is approximately 0.2 mJ for most saturated hydrocarbons. Above a certain temperature, the equilibrium mixture is richer than the upper flammability limit, and can not be ignited even with a strong spark. Recognizing the need to develop an ignition energy curve for DMSO, the work described in this report has been conducted.

As the first task, the lowest temperature where the DMSO vapors (in equilibrium with the liquid) become flammable (i.e. the Lower Flammability Limit, LFL) has been determined. If the Workstation is operated below this temperature, even a very strong ignition source can not produce self-sustaining flame propagation so long as DMSO liquid droplets are not present.

In task II, the effect of temperature on the Minimum Spark Ignition Energy of the DMSO vapor-air system in equilibrium with the DMSO liquid has been investigated. The Combustion Research Center variable energy spark generator device employed in this task is routinely used to test the Minimum Ignition Energy of combustible powders and vapors for industrial hazard evaluation.

The minimum temperature for which the Sandia generator will produce ignition has been determined in Task III. Sandia generator tests have been repeated at two additional spark gaps to determine the sensitivity of the Sandia Generator spark intensity to gap distance.

In all tests, great care has been exercised to prepare DMSO vapor – air mixtures which are in equilibrium with the liquid DMSO at the test temperature and at 664 mm Hg pressure.

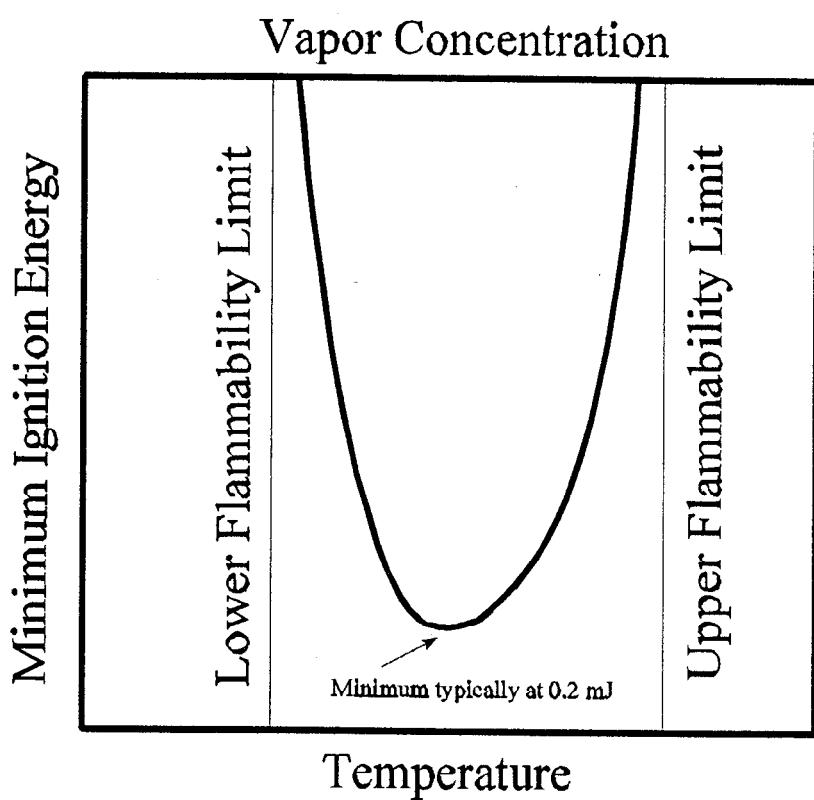


Figure 1. A schematic diagram of the minimum ignition energy of a typical hydrocarbon liquid/vapor – air system as a function of the temperature.

II

EXPERIMENTAL DETAILS

2.1. Test Apparatus:

Tests were carried out in a 7.85 liter stainless steel spherical vessel fitted with a number of ports for gas supply and exhaust vents; thermocouple; pressure transducer; igniter assembly; and a septum port for admitting liquid samples. The vessel is also fitted with a rupture vent. Additionally, the vessel has an internal flapper which allows gas agitation when the vessel is rocked from side to side. The vessel halves are clamped at the equator and a Viton O-ring seal is used. The test vessel is kept inside a temperature controlled laboratory oven.

The instrumentation included thermocouples to measure the oven temperature, 7.85 liter sphere skin temperature, as well as the gas and liquid temperatures inside the test vessel. A pressure transducer is used to monitor the pressure development inside the sphere in case the mixture is ignited. The output of the pressure transducer has been recorded using a digital data acquisition system. Calibrated test gages are used to set the initial test pressure.

Ignition attempts have been made with electric sparks as well as using chemical igniters. Since different igniter/circuit types are used in individual tasks, these details are described in the appropriate sections below.

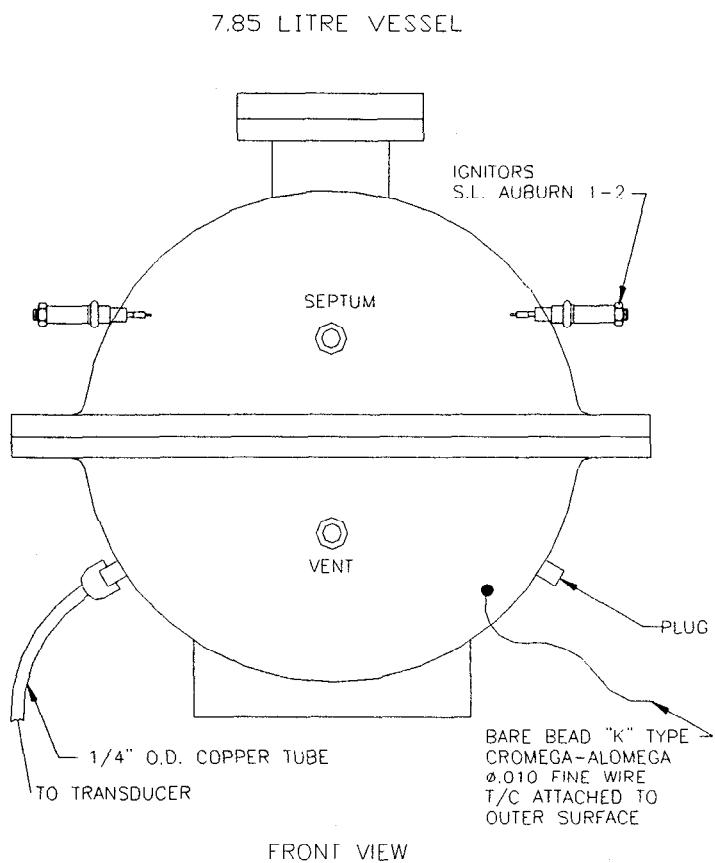


Figure 2. Front view of the 7.85 liter vessel.

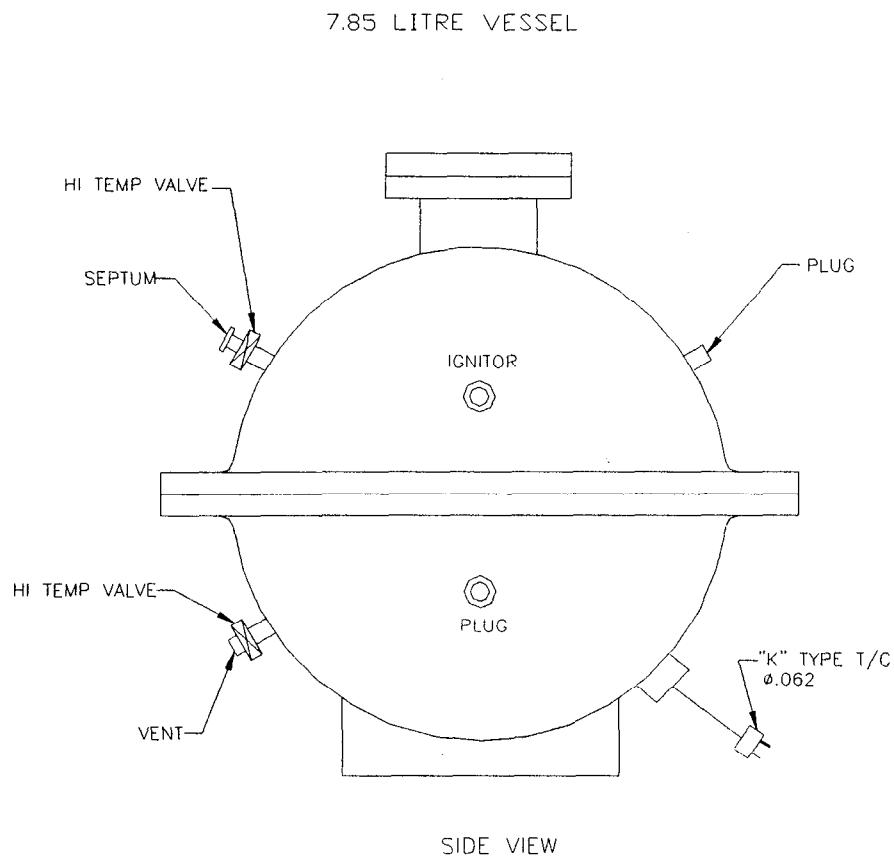


Figure 3. Side view of the 7.85 liter vessel.

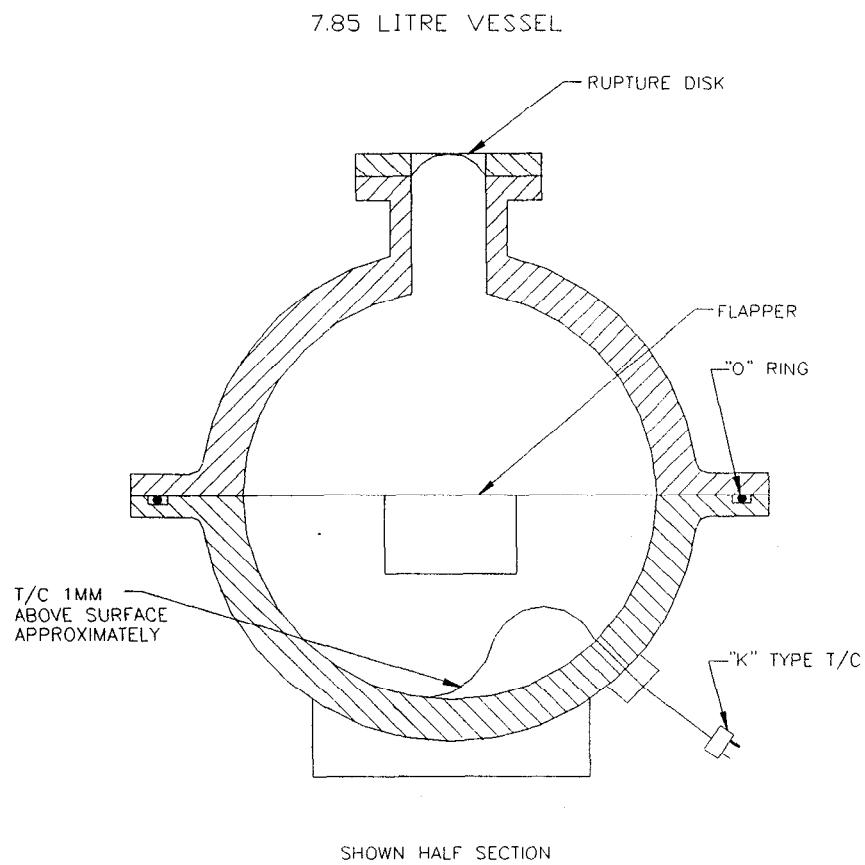


Figure 4. Cross-sectional view of the 7.85 liter vessel.

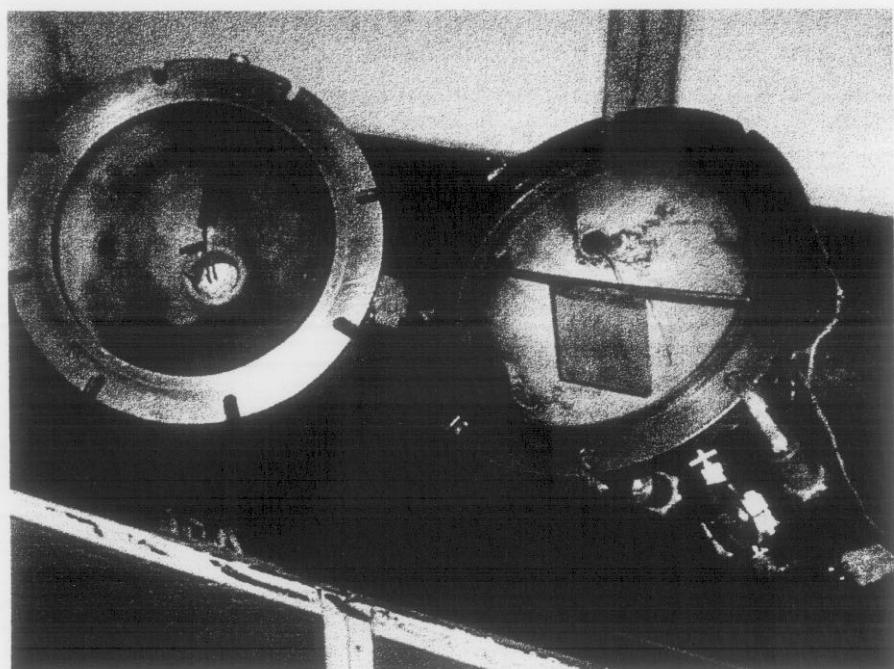


Figure 5. A photograph of the upper (left) and lower halves of the 7.85 liter vessel.

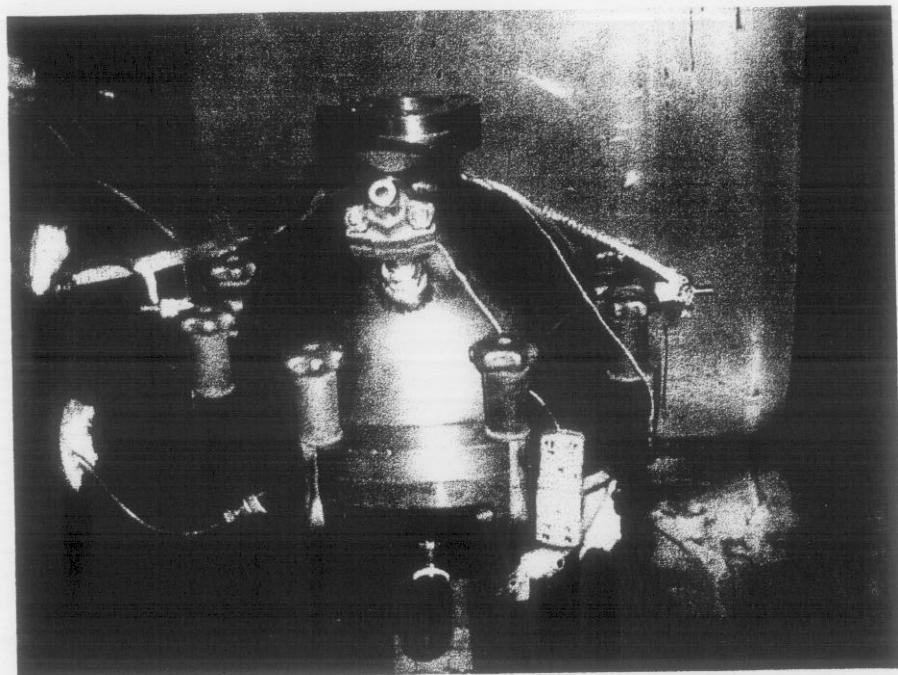


Figure 6. A photograph of the assembled 7.85 liter vessel.

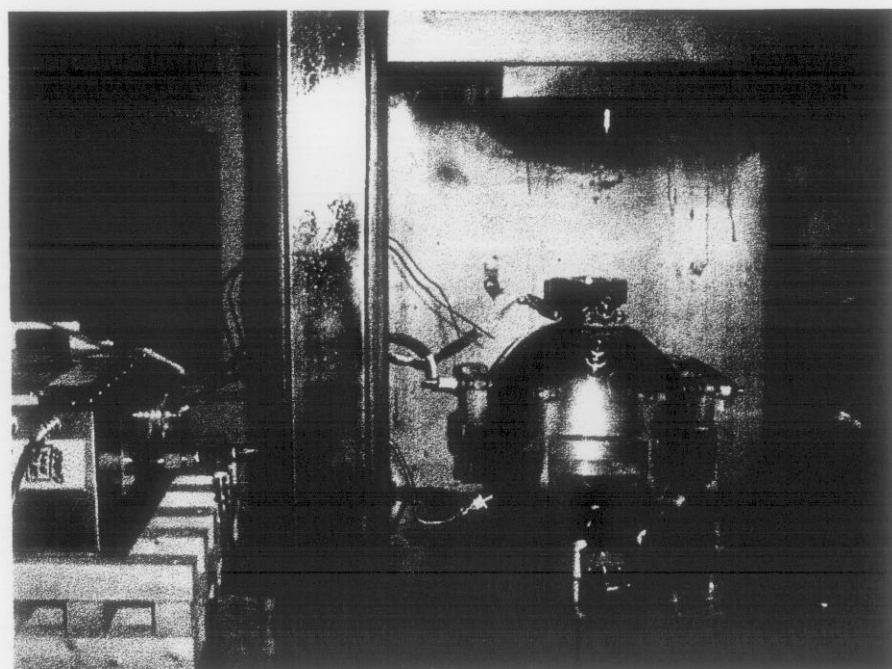


Figure 7. The 7.85 liter vessel placed in the temperature controlled industrial oven. (The oven door is removed for unobstructed photography.)

2.2. Test Procedures:

The test procedures have been designed to develop a uniform air – DMSO vapor mixture, that is in equilibrium with the liquid DMSO at the test temperature and pressure. A number of different procedures have been tried before the test procedure given below was adopted. All results given in this report were obtained using the following procedure:

- A - Clean up the test vessel
- B - Reassemble test vessel
- C - heat the test vessel slowly until it reaches 10 °F below the target test temperature
- D - inject test sample (8 ml of DMSO)
- E - Heat the vessel to target test temperature slowly while occasionally rocking it to agitate the gas mixture
- F - Reduce vessel pressure very slowly until the test pressure (664 mm Hg) is attained.
- G - Rock the vessel to agitate the gas mixture
- H - Record test temperature and actuate the igniter.

Before each test, internal surface of the vessel was thoroughly cleaned by wiping and by burning off any residue with the help of a propane torch. Thermocouple measurements indicated that, during the heat up period and at the moment of ignition, test vessel skin, vapor space and liquid DMSO temperatures were all within a fraction of a degree Fahrenheit. The quantity of the sample (4 ml of DMSO) used in the lower flammability limit tests corresponds roughly to five times the stoichiometric requirement. The sample quantity was doubled (to 8 ml of DMSO) in the minimum ignition energy and the Sandia Generator tests. The sample quantity was selected to ensure that there will always be some liquid left at the test temperature. In fact, a DMSO pool was observed at the bottom of the sphere after each test. Placing excessive quantity of sample into the test vessel as it is being heated was considered undesirable because attaining equilibrium state would take a longer time.

When the vessel is rocked from side to side the internal flapper agitates the DMSO vapors thus

eliminating any stratification that may be caused by buoyancy or by diffusion processes. Rocking the vessel also sloshes the liquid DMSO pool at the bottom of the sphere, thus greatly enhancing the effective surface areas for heat transfer from vessel to the DMSO pool, and mass transfer from DMSO pool to the vapor space.

In early tests, a thick puff of smoke was observed to rise when the test vessel was opened after an unsuccessful ignition attempt at elevated temperature. This cloud was believed to be caused by the condensation of DMSO vapors via nucleation. Once it is allowed to form, this type of cloud would take a long time to dissipate through mechanisms such as gravitational settling and Brownian diffusion. The presence of a fuel smoke can significantly affect the flame propagation and mixture ignitability. This effect has been considered in selecting the final test procedure used in this study. The procedure ensures that once the DMSO sample is introduced into the test vessel, the vessel temperature is never allowed to go above the target test temperature. Introduction of make-up air (as was used in the earlier test procedures) after the test sample is in the test vessel was not permitted, by letting the vessel pressure decrease to the test pressure very slowly and monotonously.

III

DETERMINATION OF THE LOWER FLAMMABILITY LIMIT TEMPERATURE AT REDUCED PRESSURE (664 mm Hg)

The tests are conducted in the 7.85 lt closed steel vessel described in the previous section. Flammable mixtures are identified by a pressure rise criterion. The peak pressure rise versus vapor concentration (or the liquid temperature) curve shows a marked transition at the flammability limit. This method of flammability limit measurement has been found to be more reliable and more reproducible than the old method of visual light observation in glass vessels. The ASTM Standard E 1515 employs the pressure criterion for the measurement of the Lower Flammability Limit of combustible dust clouds. A similar standard will be developed for gases and vapors. This improved technique is used by a number of testing laboratories including the Combustion Research Center.

Original test plan called for conducting the LFL experiments with a chemical igniter (electric match). The results indicated a clear delineation of a lower flammability limit. However, since a noticeable exothermic contribution was observed below the lower flammable limit, the test series were repeated using a strong electrical spark. The results are given separately below.

3.1. Chemical Igniter (Electric Match) Tests:

Commercial Regular Electric Matches¹ were used to ignite DMSO vapor – air mixtures prepared at different test temperatures using the test procedure described in Section II. The supplier indicates that these matches release an approximately 130 J of energy upon activation. A list of tests conducted using electric matches, and the resulting pressure rises are plotted in Figure 8 and also tabulated below:

¹ Procured from ICI Explosives, Atlas Powder Company, Aerospace Division, P.O. Box 271, Tamaqua, PA 18252.

Test Name	Test Temperature ($^{\circ}$ F)	Pressure Rise (psig)
a73	180.8	2.7
a74	176.8	25.29
a75	173.5	5.47
a76	170.9	2.59
a77	169.1	2.69
a78	166.1	3.1
a79	163.0	2.93
a80	151.8	2.51
a81	175.9	17.65
a82	180.8	18.31

The tests conducted at 170.9° F and at lower temperatures (down to 152° F have been tested) tend to result in an approximately 3 psig pressure rise. On the other hand, the electric match produces only 0.9 psig pressure rise when ignited in the 7.85 lt vessel in the absence of DMSO vapors. These observations indicate that at 170.9° F and lower temperatures, some localized exothermic reactions may occur, but self sustaining flame propagation is not possible.

A 5.5 psig pressure rise was observed in a test conducted at 173.5° F. Since this is noticeably above the baseline established by the tests conducted at lower temperatures, it is possible to conclude that the Lower Flammability Limit Temperature for chemical igniter is 173° F at 664 mm Hg pressure.

3.2. Strong Electrical Spark (Carbon Spark) Tests:

The Carbon Spark is a device routinely used in CRC laboratories for lower and upper flammability limit testing as well as for explosion tests where reliable strong ignition source is required. As shown in Figure 9, the carbon spark device consists of four 2 mm diameter graphite rods wrapped by the leads coming from an electrical pulse generator. The two electrical leads are separated by a 6 to 10 mm distance. The ignition circuit consists of two series wired 525μ F capacitors charged to 680 V. The resulting spark (60 J nominal energy) is in the form of a surface discharge over the graphite rods.

LFL Study at 664 mm Hg

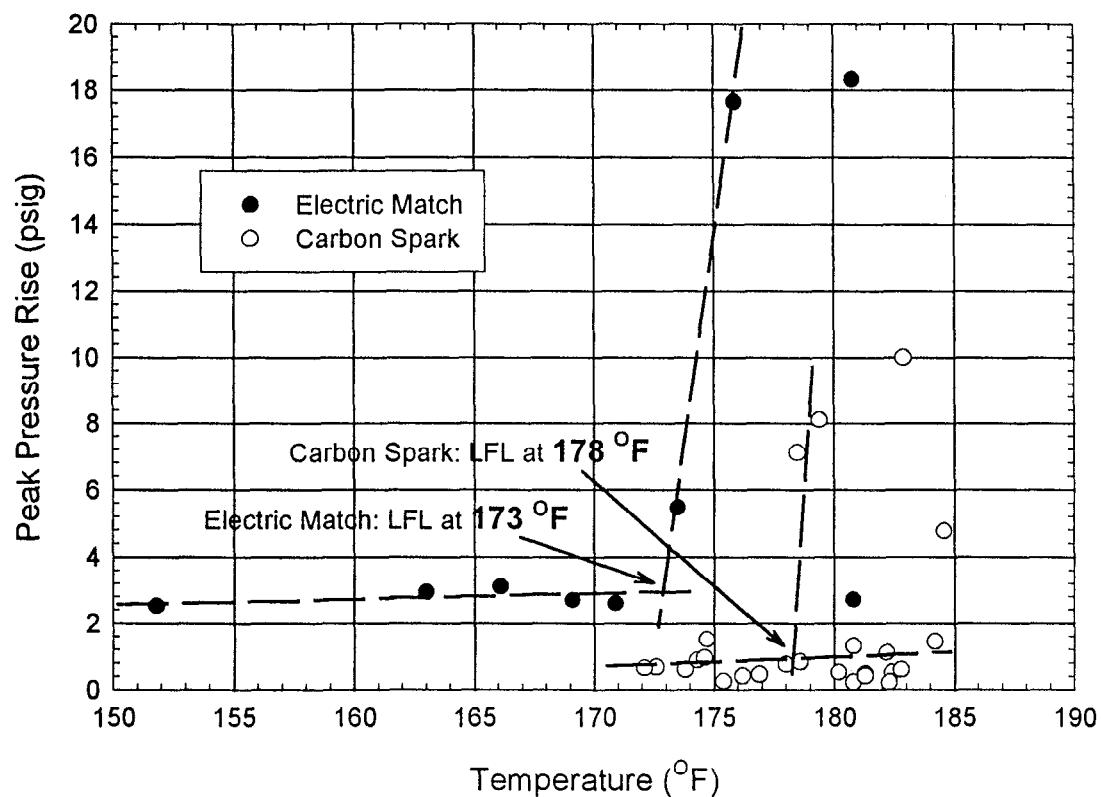


Figure 8. Peak pressure versus test temperature for Lower Flammability Limit test series.

A complete Lower Flammability Limit test series have been conducted using the Carbon Spark igniter. The results are plotted in Figure 8 and tabulated below. It is seen that in all tests conducted below 178.5 °F (except one test at 174.7 °F) the pressure rise is below 1 psig. Since the test at 174.7 °F resulted in only a 1.5 psig pressure rise, it is possible to conclude that the lower flammability limit temperature for electrical ignition is 178 °F.

Test Name	Test Temperature (°F)	Pressure Rise (psig)
A26	173.8	0.6
A27	175.7	Malfunction
A28	175.4	0.25
A29	178.6	0.83
A30	180.8	1.3
A31	178	0.75
A32	178.5	7.1
A33	174.7	1.5
A34	174.3	0.875
A35	172.6	0.68
A36	172.1	0.65
A37	176.2	0.41
A38	180.2	0.52
A39	184.2	1.44
A40	182.4	0.52
A41	182.2	1.1
A42	180.8	0.22
A64	174.6	0.95
A65	176.9	0.45
A66	179.4	8.1
A67	182.8	0.59
A68	184.6	4.76
A69	182.3	0.22
A70	182.9	9.99
A71	181.3	0.47
A72	181.3	0.41

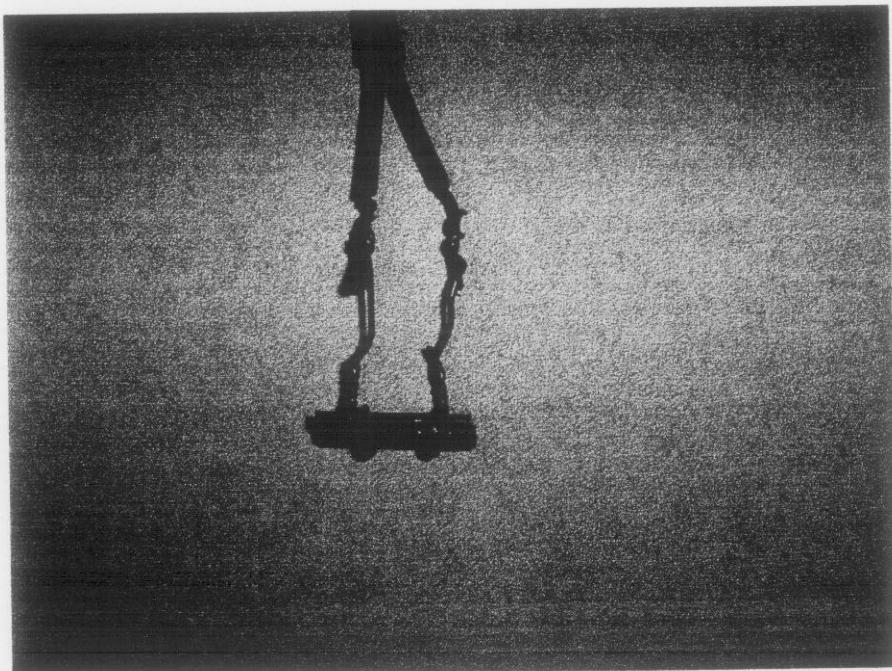


Figure 9. "Carbon Spark" ignition device used in the second test series to determine the Lower Flammability Limit.

IV

MINIMUM IGNITION ENERGY UNDER SPECIFIED CONDITIONS

A number of tests were conducted at 664 mm Hg and spanning the temperature range of interest for the Lawrence Livermore National Laboratories. Electrical sparks were generated across the gap formed by two pointed graphite electrodes positioned carefully inside the test vessel. Electrode arrangement is shown in Figure 10. In earlier studies conducted in the Combustion Research Center (CRC) laboratories, ignition performance of pointed graphite and pointed tungsten electrodes were found to be comparable. The tungsten electrodes lost their sharp point after a number of sparks but were much more difficult to sharpen when compared to the graphite electrodes. In order to provide a highly reproducible spark geometry, the graphite electrodes (2 mm in diameter) were sharpened before each test mixture was prepared.

The spark gap can be an important test parameter. The optimal spark gap is a function of the reactivity of the mixture being ignited. Generally, the optimal spark gap for reactive (near stoichiometric) mixtures is smaller than that for near limit mixtures. This issue was discussed in the determination of the project scope. Recognizing the rigid time constraints, however, it was decided to conduct the tests at a single spark gap distance rather than varying the gap to determine the optimal distance at each temperature.

Earlier LLNL study was conducted at 1 mm gap distance. This distance is believed to be too small for effective ignition. On the other hand, at large gaps (6 mm and larger) the reproducibility of the spark is compromised at low spark energies. Therefore, a 3 mm spark gap has been used in most of the tests. In few high energy spark tests where the charge voltage was high, a premature discharge occurred at 3 mm gap. In these tests, the gap was increased to 4 mm.

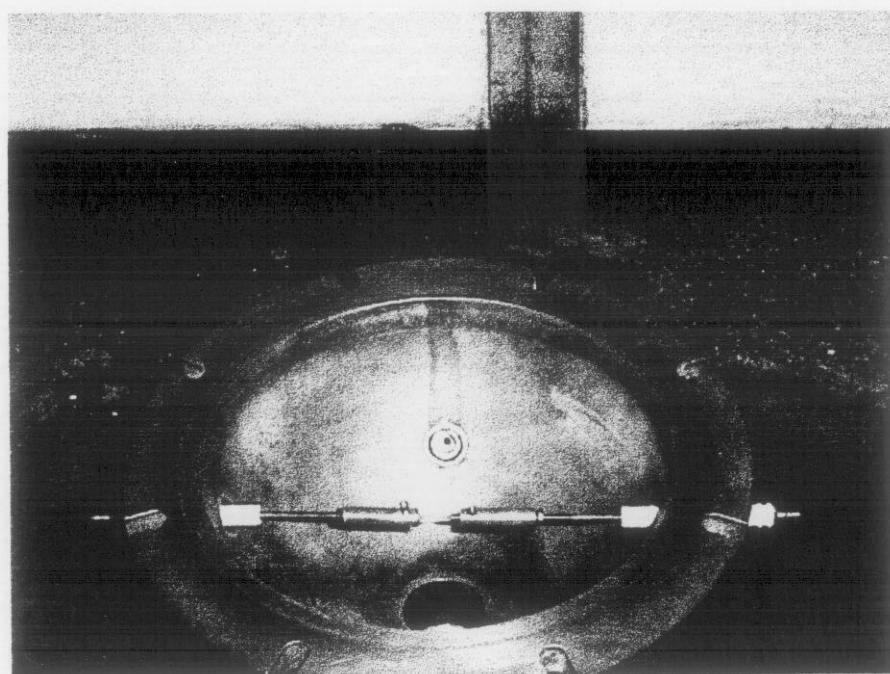


Figure 10. Photograph of the electrode arrangement. Upper hemisphere of the test vessel is shown.

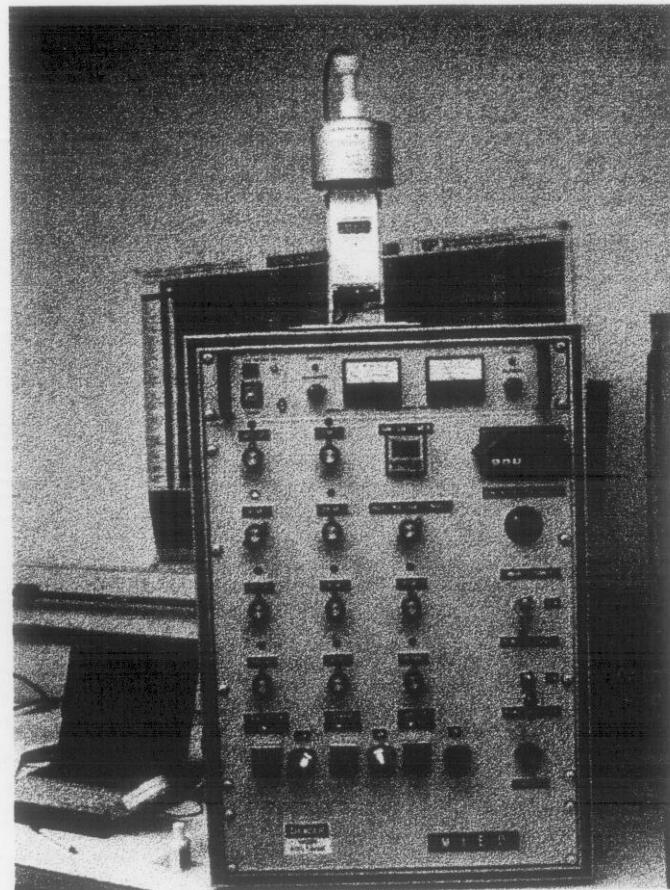


Figure 11. Photograph of the CRC electrical pulse generator used in minimum ignition energy tests.

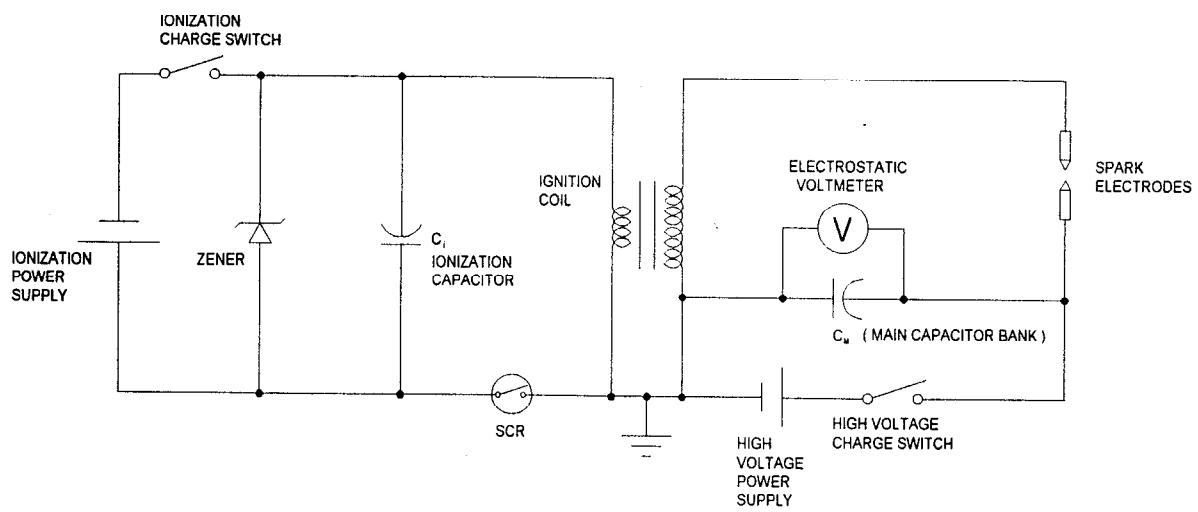


Figure 12. A schematic diagram of the CRC electrical pulse generator used in minimum ignition energy tests.

The sparks were produced using the CRC pulse generator shown in Figures 11 and 12. This device is routinely used to determine the minimum ignition energy of combustible powders or vapors dispersed in air. The electrical configuration of the CRC pulse generator is being considered for adoption in a new ASTM standard (currently being developed) test method for Minimum Ignition Energy of Dust-Air Mixtures.

The CRC pulse generator is a multi-capacitor apparatus, shown in Figure 11, housing a variable high voltage power supply. This device is capable of generating single electric sparks in the range from a few mJ up to 20 J. The spark circuit, schematically shown in Figure 12, contains two capacitive components: an ionization capacitor; and a High Voltage (HV) capacitor bank. The ionization capacitor has a capacitance of 0.47 μF and is charged to a voltage typically between 160 and to 200 V. This capacitor contributes up to 9.4 mJ to the total spark energy. The HV capacitor is selected from a bank of capacitors having values from 0.005 to 0.5 μF . The HV capacitor is charged to voltages below the break-down voltage of the prescribed electrode gap, typically from 500 to 4000 V. On triggering the ionization capacitor, energy is discharged through an ignition coil resulting in a voltage pulse of several thousand volts at the electrodes, thus ionizing the field in the electrode gap. Once the field is ionized, the HV capacitors also discharge through the electrode gap. The gap between electrode tips is maintained typically in the range between 3 and 6 mm. The pre-discharge and the post-discharge voltages of the HV capacitor are measured using a calibrated JCI-148 electrostatic volt-meter. The energy, E, delivered at the spark gap is calculated using the equation:

$$E = \frac{1}{2} C_i * V_{ion} + \frac{1}{2} C_M * [V_{initial}^2 - V_{final}^2]_{main} \quad (1)$$

where:

C_i : Ionization Circuit capacitance (0.47 μF),

V_{ion} : Ionization capacitor charge voltage,

C_M : Capacitor Bank capacitance (variable),

$V_{initial}$: Initial voltage of the main capacitor bank, and

V_{final} : Final voltage of the main capacitor bank.

The capacitance and voltage settings used in all tests, as well as the final voltage of the capacitor bank measured using the electrostatic volt meter are tabulated in the Appendix.

Since the test temperature and the spark energy are independently controlled parameters, each ignition attempt can be represented by a point on the plot given in Figure 13. For the sake of clarity, only those tests resulting in ignition are shown in Figure 13 with the open circles. These points clearly define a trend where the minimum ignition energy decreases as the mixture temperature increases from 185 °F to 216 °F. A curve drawn to envelope these data points may be used to establish the safety margin of the planned operation.

It should also be pointed out that low energy spark ignition is a highly probabilistic process. In many more tests than those shown in Figure 13, the spark was not capable of igniting the mixture. Those tests where the mixture did not ignite are shown with diamonds in Figure 14.

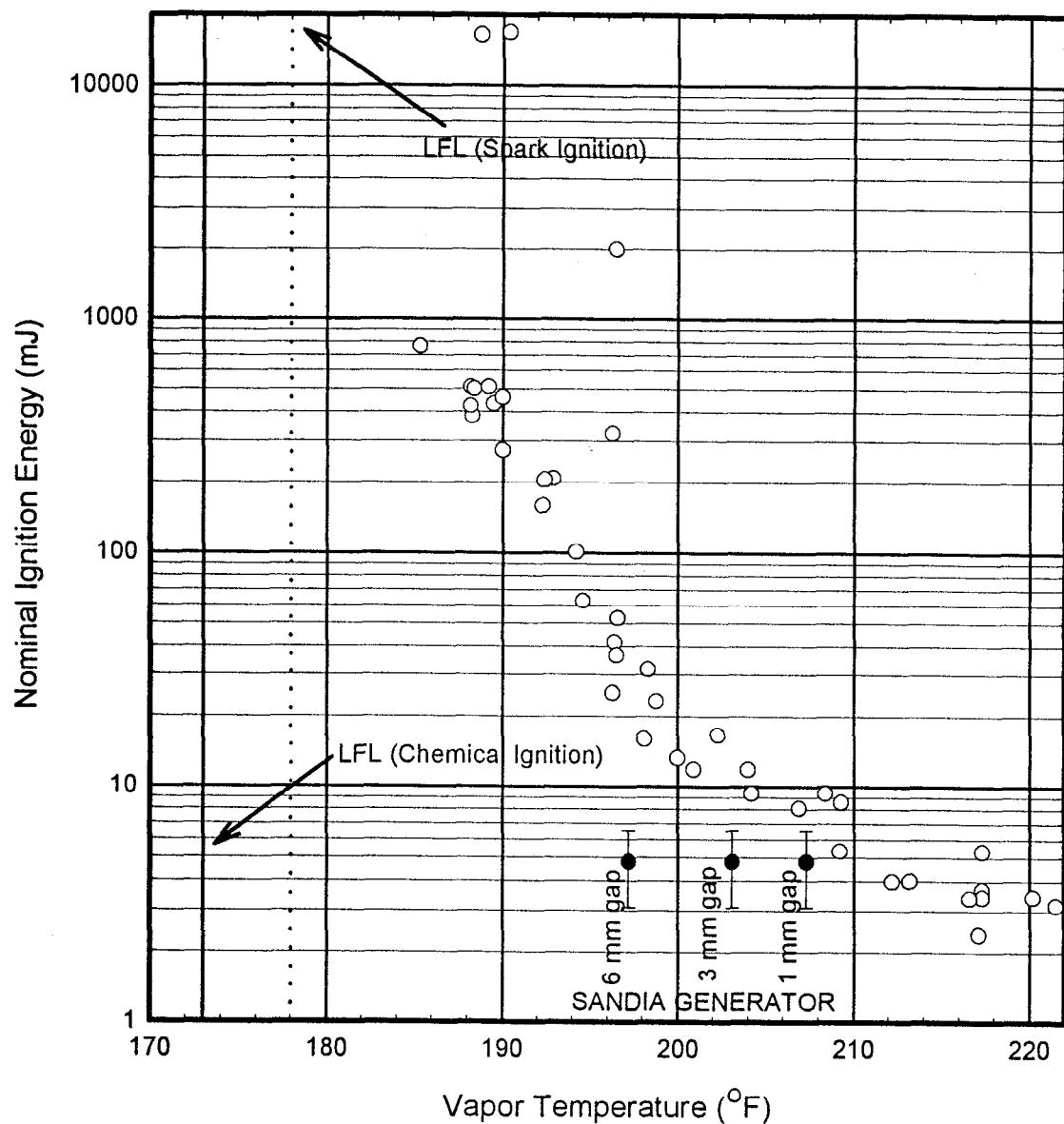


Figure 13. Summary of Test results

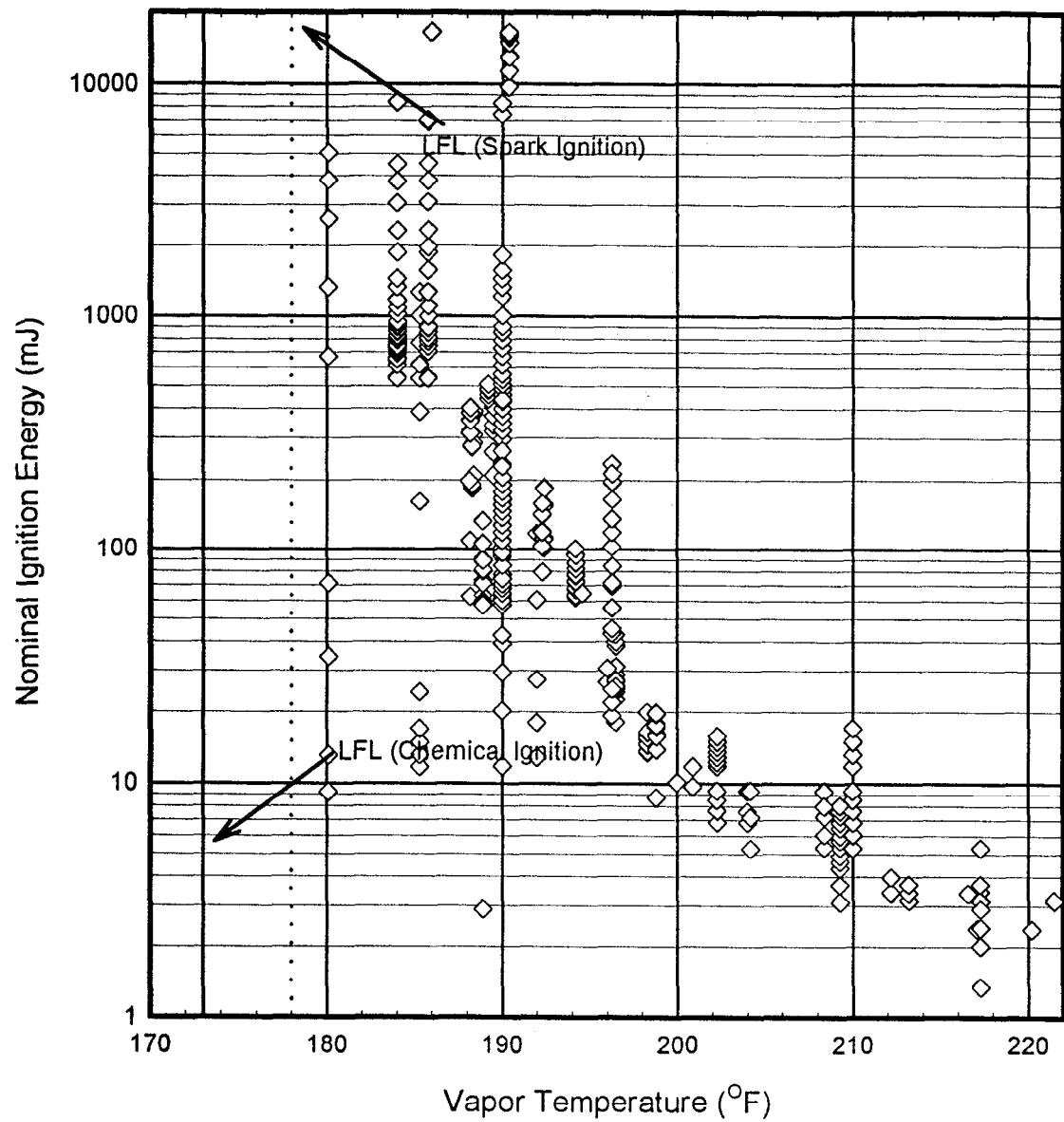


Figure 14. Minimum ignition energy tests where the spark did not ignite the test mixture.

V

IGNITION TEMPERATURE FOR SANDIA SPARK GENERATOR

The Sandia Spark Generator has been provided by the Lawrence Livermore National Laboratories. The unit has been operated according to the accompanying instructions. In all tests reported in this section, the device was operated without the ferrite and the charge setting was 30 kV.

In order to minimize cable length requirements, the Sandia Generator was placed as close to the oven wall as possible (see Figure 7). One of the spark electrodes was connected to the lead coming from the Sandia generator using a commercial spark plug cable. The total length of this cable, from one termination to other, was 18 inches. Since the electrode assembly is 6 inches long, the total distance from the Sandia Generator output port to the tip of the spark was 24 inches. The other spark electrode was connected to the ground using a ground strap.

Since the Sandia Generator is a high voltage device the spark gap was initially set at 6 mm. The test mixtures were prepared as described in Section II. The results summarized on the next page indicate that the test mixtures can be ignited at temperatures as low as 197 °F. This data point is also shown on Figure 13 along with the data collected using the CRC pulse generator. The vertical position (with the error bars) of this point denote the LLNL spark energy measurement range. The Sandia Generator point for 6 mm spark gap is seen to fall significantly below the curve developed using the CRC pulse generator.

Because of this unexpected finding, the tests were repeated at two additional spark gaps; namely at 3 mm and at 1 mm. Those results are also tabulated in the following pages. It is seen that the Sandia Generator can ignite test mixtures at temperatures as low as 203 °F when the spark gap is 3 mm, and at 207 °F with 1 mm gap. Interestingly, the point for 1 mm gap appears to fall on the curve developed using the CRC pulse generator (see Figure 13). Since the Sandia spark energy values used to plot

these points were measured at 1 mm spark gap, the data may be indicating that the Sandia Generator is not a constant energy spark device, but instead the energy of the spark generated increases with the increasing spark gap.

Sandia Generator: 6 mm electrode spacing

Test Name	Temperature (°F)	Result
B71	210.1	Ignition
B72	206.2	Ignition
B73	192.8	No Ign.
B74	194.7	No Ign.
B75	196.1	No Ign.
B76	197.5	No Ign.
B77	198	Ignition
B78	193	No Ign.
B79	194.7	No Ign.
B80	195.4	No Ign.
B81	196.6	No Ign.
B82	197.3	Ignition
B83	198.4	No Ign.
B84	198.5	Ignition
B85	199.6	Ignition
B86	197.5	No Ign.
B87	198.4	Ignition
B88	200.2	No Ign.
B89	207.8	Ignition
B90	200.3	Ignition
B91	197.2	Ignition
B92	201.5	Ignition

Sandia Generator: 3 mm electrode spacing

Test Name	Temperature (°F)	Result
B93	198.1	No Ign.
B94	199	No Ign.
B95	200	No Ign.
B96	201.3	No Ign.
B97	201.9	No Ign.
B98	203.3	No Ign.
B99	203.3	Ignition
C01	200.5	No Ign.
C02	201.4	No Ign.
C03	202.9	No Ign.
C04	203.1	Ignition

Sandia Generator: 1 mm electrode spacing

Test Name	Temperature (°F)	Result
C05	197.9	No Ign.
C06	199.1	No Ign.
C07	200	No Ign.
C08	200.4	No Ign.
C09	201.9	No Ign.
C10	202.1	No Ign.
C11	203	No Ign.
C12	204.3	No Ign.
C13	207.3	Ignition
C14	205.6	No Ign.
C15	207.1	No Ign.
C16	207.5	No Ign.
C17	208.5	Ignition
C18	207.3	Ignition

VI

SUMMARY OF RESULTS

Ignitability of DMSO vapors have been evaluated at 664 mm Hg pressure. The minimum temperature at which the DMSO vapors that are in equilibrium with liquid DMSO has been determined using two types of strong ignition sources. This temperature is 172 °F for chemical igniters, and 178 °F for spark ignition.

Numerous tests have been conducted using controlled intensity sparks to define the shape of the minimum ignition energy curve as a function of temperature. The ignition energies spanned four orders of magnitude (approximately from 20000 to 2 mJ) while the DMSO vapor mixture temperature varied from 185 to 207 °F.

The Sandia Generator was used to simulate worst case electrostatic sparks that can be produced by the human body. Although it was not designed for air discharges, this device had been used by LLNL for 1 mm spark gap and the resultant spark energy had been measured to fall within the range from 3.2 to 8.8 mJ. CRC tests using this device showed that the minimum ignition temperature strongly depends on the spark gap. The minimum ignition temperature was 207 °F at 1 mm spark gap, 203 °F at 3 mm spark gap, and 197 °F at 6 mm spark gap. This strong dependence on the spark gap is believed to be partly due to the changes in the spark energy as the spark gap changes.

APPENDIX

A LISTING OF THE ELECTRICAL PARAMETERS USED FOR TESTS REPORTED IN SECTION IV

MIXTURE	TEMPERATURE	SPARK ENERGY	TEST RESULT ²	Ionization power supply volts	capacitor bank setting μF	capacitor bank initial voltage	capacitor bank final voltage
label	deg. F	mJ	(psig)				
b17	204	6.8		170.3	0	0	0
b17	204	7.6		180.1	0	0	0
b17	204	9.3		198.9	0	0	0
b17	204	11.8	11.8	198.9	0.005	1000	0
b18	200	10.1		180.3	0.005	1000	0
b18	200	13.2	11.79	198.7	0.005	1250	0
b19	180.1	13.1		197.6	0.005	1250	0
b19	180.1	14.8		197.6	0.005	1500	106
b19	180.1	16.8		197.6	0.005	1750	0
b19	180.1	19.2		197.5	0.005	2000	0
b19	180.1	21.8		197.2	0.005	2250	0
b19	180.1	34.4		197.2	0.01	2250	60
b19	180.1	40.4		197.5	0.01	2500	0
b19	180.1	71.4		197.5	0.02	2500	157
b19	180.1	670.4		197.6	0.25	2300	0
b19	180.1	1329.7		197.5	0.5	2300	88
b19	180.1	2604.9		198.1	1	2300	314
b19	180.1	3850.0		198.2	1.5	2300	411
b19	180.1	5047.9		197.9	1.935	2330	470
b20	185.3	11.7		198.1	0.005	1000	0
b20	185.3	13.1		197.9	0.005	1250	0
b20	185.3	14.8		197.6	0.005	1500	0
b20	185.3	16.8		197.8	0.005	1750	40
b20	185.3	24.3		198	0.01	1750	214
b20	185.3	762.5	5.18	197.4	0.5	1750	222
b20	185.3	161.0		196.9	0.1	1750	160
b20	185.3	388.8		196.9	0.25	1750	158
b20	185.3	539.8		197	0.35	1750	174
b20	185.3	617.3		197	0.4	1750	147
b20	185.3	668.9		197.1	0.435	1750	170
b20	185.3	667.0		197.1	0.435	1750	195
b20	185.3	768.6		196.6	0.5	1750	156
b20	185.3	1005.2		197.2	0.5	2000	125
b20	185.3	1271.9		198.5	0.5	2250	109

² Any entry in this column designates that that particular test has resulted in ignition.

CRC Technical Report SSR-1945/SO-45930

b21	188.2	62.6		198.9	0.05	1500	346
b21	188.2	108.3		199	0.05	2000	197
b21	188.2	508.7	8.35	199.1	0.25	2000	70
b22	188.4	208.7		198.9	0.1	2000	107
b22	188.4	308.9		199	0.15	2000	72
b22	188.4	378.9		199	0.185	2000	68
b22	188.4	287.5		199.2	0.25	1500	158
b22	188.4	390.7		199.2	0.25	1750	108
b22	188.4	506.9	7.64	175	0.25	2000	50
b23	192.9	206.9	9.16	174.8	0.1	2000	71
b24	192	12.8		174.9	0.005	1500	40
b24	192	17.9		174.9	0.01	1500	340
b24	192	27.5		175	0.02	1500	474
b24	192	60.7		175.1	0.05	1500	329
b24	192	117.0		175.1	0.1	1500	231
b25	196.5	18.0		175.3	0.01	1500	314
b25	196.5	22.6		175.1	0.015	1500	437
b25	196.5	24.3		190.6	0.015	1500	385
b25	196.5	25.0		199	0.015	1500	393
b25	196.5	29.0		175.4	0.015	1750	397
b25	196.5	31.4		198.9	0.015	1750	348
b25	196.5	38.3		199.1	0.02	1750	410
b25	196.5	39.9		199.2	0.02	1800	424
b25	196.5	43.1		199.2	0.025	1700	438
b25	196.5	2003.1	9.2	199.1	1.935	1500	435
b26	196.3	43.6		176	0.025	1750	400
b26	196.3	45.7		199.1	0.025	1750	390
b26	196.3	56.1		175.8	0.025	2000	302
b26	196.3	69.7		175.8	0.025	2250	257
b26	196.3	71.7		198.9	0.025	2250	268
b26	196.3	84.4		199.2	0.03	2250	239
b26	196.3	102.5		199	0.03	2500	196
b26	196.3	118.3		199	0.035	2500	139
b26	196.3	135.6		199.2	0.05	2250	101
b26	196.3	165.3		199.2	0.05	2500	104
b26	196.3	194.5		175.6	0.06	2500	95
b26	196.3	196.8		198.7	0.06	2500	9
b26	196.3	234.1		175.7	0.06	2750	0
b26	196.3	212.4		199	0.065	2500	0
b26	196.3	212.4		199.3	0.065	2500	30
b26	196.3	212.5		199.3	0.065	2500	0
b26	196.3	321.8	8.37	199.3	0.1	2500	0

CRC Technical Report SSR-1945/SO-45930

b27	196.6	52.7	8.64	199.6	0.1	1000	366
b27	196	26.8		175.6	0.035	1250	667
b27	196	30.8		199.8	0.035	1250	583
b28	196.4	41.5	9.3	199.8	0.035	1500	642
b29	209.2	5.3	No Record	150.6	0	0	0
b30	209.3	3.1		115.1	0	0	0
b30	209.3	3.7		125.2	0	0	0
b30	209.3	4.3		135.9	0	0	0
b30	209.3	4.6		140.3	0	0	0
b30	209.3	4.9		144.9	0	0	0
b30	209.3	5.3		150.8	0	0	0
b30	209.3	5.7		156	0	0	0
b30	209.3	6.0		159.5	0	0	0
b30	209.3	6.5		166	0	0	0
b30	209.3	6.8		170.5	0	0	0
b30	209.3	7.3		175.9	0	0	0
b30	209.3	7.6		180.2	0	0	0
b30	209.3	8.1		185.3	0	0	0
b30	209.3	8.6	15.23	190.8	0	0	0
b31	213.2	3.2		116.2	0	0	0
b31	213.2	3.4		120.3	0	0	0
b31	213.2	3.7		125.4	0	0	0
b31	213.2	4.0	14.89	130.4	0	0	0
b32	217.3	3.2		116	0	0	0
b32	217.3	3.4		121.1	0	0	0
b32	217.3	3.7	15.01	125.1	0	0	0
b33	217.3	3.1		115.7	0	0	0
b33	217.3	3.4	15.72	120.4	0	0	0
b34	221.5	3.2		115.8	0	0	0
b34	221.5	3.2		115.8	0	0	0
b34	221.5	3.2		115.9	0	0	0
b34	221.5	3.2	15.65	115.9	0	0	0
		112.6		198.5	0.1	1500	427
b36	188.9	63.3		199	0.05	1500	299
b36	188.9	59.8		198.8	0.05	1500	480
b36	188.9	58.9		199	0.05	1500	516
b36	188.9	57.4		199	0.05	1500	572
b36	188.9	59.1		198.9	0.05	1500	506
b36	188.9	73.4		198.9	0.05	1650	400
b36	188.9	71.4		198.9	0.05	1650	488
b36	188.9	71.2		198.8	0.05	1650	494

CRC Technical Report SSR-1945/SO-45930

b36	188.9	71.2	198.6	0.05	1650	496	
b36	188.9	80.2	198.7	0.05	1750	475	
b36	188.9	80.4	198.8	0.05	1750	466	
b36	188.9	80.5	198.6	0.05	1750	460	
b36	188.9	81.7	198.5	0.05	1750	405	
b36	188.9	89.2	198.7	0.05	1850	475	
b36	188.9	89.0	198.7	0.05	1850	484	
b36	188.9	90.7	198.5	0.05	1850	408	
b36	188.9	90.6	198.7	0.05	1850	411	
b36	188.9	89.6	198.7	0.05	1850	460	
b36	188.9	105.3	198.7	0.05	2000	400	
b36	188.9	105.9	198.6	0.05	2000	365	
b36	188.9	105.3	198.6	0.05	2000	400	
b36	188.9	105.3	198.6	0.05	2000	400	
b36	188.9	105.4	198.5	0.05	2000	394	
b36	188.9	133.2	198.3	0.05	2250	325	
b36	188.9	132.4	198.3	0.05	2250	370	
b36	188.9	132.5	198.4	0.05	2250	362	
b37	192.4	112.7	198.7	0.1	1500	426	
b37	192.4	110.5	198.7	0.1	1500	475	
b37	192.4	110.4	198.6	0.1	1500	477	
b37	192.4	111.0	198.6	0.1	1500	464	
b37	192.4	110.2	198.6	0.1	1500	480	
b37	192.4	154.0	198.5	0.1	1750	410	
b37	192.4	156.8	198.5	0.1	1750	335	
b37	192.4	154.4	198.7	0.1	1750	400	
b37	192.4	156.3	198.4	0.1	1750	348	
b37	192.4	154.1	198.6	0.1	1750	408	
b37	192.4	184.3	198.8	0.1	1900	330	
b37	192.4	186.1	198.7	0.1	1900	270	
b37	192.4	184.7	198.8	0.1	1900	318	
b37	192.4	185.1	198.8	0.1	1900	305	
b37	192.4	183.4	198.7	0.1	1900	358	
b37	192.4	204.0	8.76	198.7	0.11	1900	265
b38	196.5	26.8	199.1	0.03	1250	630	
b38	196.5	27.5	199.1	0.03	1250	590	
b38	196.5	27.3	199	0.03	1250	600	
b38	196.5	25.2	198.9	0.03	1250	711	
b38	196.5	25.7	199	0.03	1250	685	
b38	196.5	36.5	10.6	199	0.03	1500	660
b39	200.9	9.7	175.2	0.005	1000	0	
b39	200.9	9.7	175.3	0.005	1000	0	

CRC Technical Report SSR-1945/SO-45930

b39	200.9	9.7		175.3	0.005	1000	19
b39	200.9	9.7		175.3	0.005	1000	34
b39	200.9	9.7		175.3	0.005	1000	0
b39	200.9	11.8		198.5	0.005	1000	0
b39	200.9	11.8		198.6	0.005	1000	0
b39	200.9	11.8	14.65	198.7	0.005	1000	0
b40	204.2	5.3		150	0	0	0
b40	204.2	5.3		150	0	0	0
b40	204.2	5.3		150.1	0	0	0
b40	204.2	5.3		150.1	0	0	0
b40	204.2	5.3		150.1	0	0	0
b40	204.2	7.2		175.2	0	0	0
b40	204.2	7.2		175.2	0	0	0
b40	204.2	7.2		175.2	0	0	0
b40	204.2	7.2		175.2	0	0	0
b40	204.2	7.2		175.1	0	0	0
b40	204.2	9.3		199.3	0	0	0
b40	204.2	9.3	No	199.3	0	0	0
			pressure ris				
b41	208.4	5.4		151	0	0	0
b41	208.4	5.4		151	0	0	0
b41	208.4	5.4		150.9	0	0	0
b41	208.4	5.3		150.8	0	0	0
b41	208.4	5.3		150.8	0	0	0
b41	208.4	6.1		160.6	0	0	0
b41	208.4	6.1		160.6	0	0	0
b41	208.4	6.1		160.6	0	0	0
b41	208.4	6.1		160.6	0	0	0
b41	208.4	6.1		160.6	0	0	0
b41	208.4	7.2		175.6	0	0	0
b41	208.4	7.2		175.6	0	0	0
b41	208.4	7.2		175.5	0	0	0
b41	208.4	7.3		175.7	0	0	0
b41	208.4	7.2		175.6	0	0	0
b41	208.4	9.3		198.8	0	0	0
b41	208.4	9.3		198.7	0	0	0
b41	208.4	9.3	14.87	198.9	0	0	0
b42	212.2	3.4		120.5	0	0	0
b42	212.2	3.4		120.5	0	0	0
b42	212.2	3.4		120.5	0	0	0
b42	212.2	3.4		120.5	0	0	0

CRC Technical Report SSR-1945/SO-45930

b42	212.2	3.4		120.6	0	0	0
b42	212.2	4.0		130.2	0	0	0
b42	212.2	4.0		130.2	0	0	0
b42	212.2	4.0	15.82	130.2	0	0	0
b43	216.6	3.4		120	0	0	0
b43	216.6	3.4	16.04	120	0	0	0
b44	217.1	2.4		100.7	0	0	0
b44	217.1	2.4		100.7	0	0	0
b44	217.1	2.4	14.65	100.6	0	0	0
b45	217.3	0.9		60.9	0	0	0
b45	217.3	0.9		60.9	0	0	0
b45	217.3	0.9		60.9	0	0	0
b45	217.3	0.9		60.9	0	0	0
b45	217.3	0.9		60.9	0	0	0
b45	217.3	1.4		75.8	0	0	0
b45	217.3	1.4		75.9	0	0	0
b45	217.3	1.4		75.9	0	0	0
b45	217.3	1.4		75.9	0	0	0
b45	217.3	1.4		75.9	0	0	0
b45	217.3	2.0		92.8	0	0	0
b45	217.3	2.0		92.8	0	0	0
b45	217.3	2.0		92.8	0	0	0
b45	217.3	2.0		92.8	0	0	0
b45	217.3	2.4		101.3	0	0	0
b45	217.3	2.4		101.3	0	0	0
b45	217.3	2.4		101.3	0	0	0
b45	217.3	2.4		101.3	0	0	0
b45	217.3	2.4		101.3	0	0	0
b45	217.3	2.9		111.4	0	0	0
b45	217.3	2.9		111.3	0	0	0
b45	217.3	2.9		111.3	0	0	0
b45	217.3	2.9		111.3	0	0	0
b45	217.3	2.9		111.3	0	0	0
b45	217.3	3.7		125.3	0	0	0
b45	217.3	3.7		125.3	0	0	0
b45	217.3	3.7		125.3	0	0	0
b45	217.3	3.7		125.3	0	0	0
b45	217.3	3.7		125.3	0	0	0
b45	217.3	5.3		150.3	0	0	0
b45	217.3	5.3	15.38	150.3	0	0	0

CRC Technical Report SSR-1945/SO-45930

b46	220.2	2.4		100.4	0	0	0
b46	220.2	2.4		100.4	0	0	0
b46	220.2	2.4		100.4	0	0	0
b46	220.2	2.4		100.4	0	0	0
b46	220.2	2.4		100.4	0	0	0
b46	220.2	3.4	18.34	120.8	0	0	0
b47	192.3	79.5		199.3	0.06	1550	250
b47	192.3	103.6		199.2	0.085	1500	180
b47	192.3	102.3		198.9	0.085	1500	250
b47	192.3	103.0		199	0.085	1500	215
b47	192.3	103.1		199	0.085	1500	205
b47	192.3	102.7		199	0.085	1500	230
b47	192.3	119.4		199.3	0.1	1500	222
b47	192.3	118.7		199.3	0.1	1500	250
b47	192.3	118.4		199.3	0.1	1500	262
b47	192.3	119.5		199.3	0.1	1500	217
b47	192.3	118.6		199.3	0.1	1500	255
b47	192.3	141.7		199.3	0.12	1500	211
b47	192.3	141.2		199.2	0.12	1500	227
b47	192.3	141.6		199.2	0.12	1500	212
b47	192.3	141.9		199.2	0.12	1500	200
b47	192.3	141.6		199.2	0.12	1500	215
b47	192.3	157.9		198.8	0.135	1500	220
b47	192.3	158.3	9.89	198.9	0.135	1500	207
b48	188.3	189.3		199.1	0.25	1250	350
b48	188.3	183.3		199.1	0.25	1250	413
b48	188.3	189.0		199	0.25	1250	353
b48	188.3	187.7		199	0.25	1250	368
b48	188.3	191.6		198.8	0.25	1250	323
b48	188.3	279.1		180.8	0.25	1500	281
b48	188.3	280.7		180.8	0.25	1500	257
b48	188.3	277.5		180.8	0.25	1500	302
b48	188.3	278.7		180.8	0.25	1500	286
b48	188.3	274.1		180.8	0.25	1500	345
b48	188.3	278.9		180.8	0.25	1500	283
b48	188.3	383.1	6.42	180.6	0.25	1750	243
b49	188.2	316.2		150.8	0.25	1600	270
b49	188.2	314.3		150.9	0.25	1600	298
b49	188.2	314.9		150.9	0.25	1600	289
b49	188.2	315.4		150.9	0.25	1600	282
b49	188.2	317.7		150.9	0.25	1600	248
b49	188.2	315.8		175.5	0.25	1600	303

b49	188.2	318.9	175.6	0.25	1600	259	
b49	188.2	321.4	198.5	0.25	1600	251	
b49	188.2	319.9	198.8	0.25	1600	274	
b49	188.2	319.3	198.8	0.25	1600	283	
b49	188.2	316.9	198.8	0.25	1600	315	
b49	188.2	315.7	198.8	0.25	1600	330	
b49	188.2	357.9	150.4	0.25	1700	263	
b49	188.2	357.5	150.4	0.25	1700	270	
b49	188.2	357.7	150.5	0.25	1700	266	
b49	188.2	358.7	150.6	0.25	1700	251	
b49	188.2	355.2	150.6	0.25	1700	302	
b49	188.2	381.4	198.8	0.25	1750	292	
b49	188.2	383.2	198.7	0.25	1750	266	
b49	188.2	385.7	198.8	0.25	1750	226	
b49	188.2	383.5	198.7	0.25	1750	262	
b49	188.2	383.0	198.8	0.25	1750	270	
b49	188.2	404.0	150.9	0.25	1800	226	
b49	188.2	405.3	150.7	0.25	1800	200	
b49	188.2	405.3	150.8	0.25	1800	200	
b49	188.2	403.4	150.6	0.25	1800	235	
b49	188.2	404.1	150.7	0.25	1800	224	
b49	188.2	403.1	150.6	0.25	1800	241	
b49	188.2	423.3	7.62	150.5	0.25	1850	280
b50	184	639.6	198.6	0.25	2250	141	
b50	184	640.7	198.6	0.25	2250	107	
b50	184	639.6	198.4	0.25	2250	139	
b50	184	640.5	198.6	0.25	2250	113	
b50	184	640.6	198.8	0.25	2250	109	
b50	184	640.4	198.8	0.25	2250	117	
b50	184	668.9	198.7	0.25	2300	113	
b50	184	669.0	198.7	0.25	2300	112	
b50	184	669.2	198.6	0.25	2300	102	
b50	184	669.2	198.7	0.25	2300	104	
b50	184	668.8	198.6	0.25	2300	116	
b50	184	698.1	198.7	0.25	2350	108	
b50	184	698.3	198.7	0.25	2350	103	
b50	184	698.4	198.8	0.25	2350	99	
b50	184	698.4	198.7	0.25	2350	99	
b50	184	698.2	198.7	0.25	2350	104	
b50	184	727.6	198.7	0.25	2400	116	
b50	184	727.2	198.7	0.25	2400	128	
b50	184	727.2	198.7	0.25	2400	129	

CRC Technical Report SSR-1945/SO-45930

b50	184	726.6	198.6	0.25	2400	147
b50	184	727.8	198.7	0.25	2400	107
b50	184	712.7	198.7	0.5	1700	276
b50	184	755.3	198.9	0.5	1750	280
b50	184	752.1	198.8	0.5	1750	302
b50	184	750.6	199	0.5	1750	312
b50	184	758.4	199.1	0.5	1750	257
b50	184	755.3	199.1	0.5	1750	280
b50	184	799.7	198.9	0.5	1800	280
b50	184	794.5	198.9	0.5	1800	315
b50	184	768.1	198	1	1300	415
b50	184	824.2	198.9	1	1350	439
b50	184	818.8	198.9	1	1350	451
b50	184	804.4	199	1	1350	482
b50	184	545.4	199.1	0.43	1600	258
b50	184	542.4	199	0.43	1600	284
b50	184	545.4	199	0.43	1600	258
b50	184	537.8	199	0.43	1600	319
b50	184	537.7	199	0.43	1600	320
b50	184	616.1	199.1	0.43	1700	260
b50	184	614.5	199.1	0.43	1700	274
b50	184	616.8	199.1	0.43	1700	254
b50	184	618.4	199.1	0.43	1700	239
b50	184	615.3	199.1	0.43	1700	267
b50	184	649.8	199.1	0.43	1750	289
b50	184	652.0	199	0.43	1750	271
b50	184	655.4	199.1	0.43	1750	240
b50	184	654.5	199	0.43	1750	248
b50	184	655.6	198.9	0.43	1750	238
b50	184	692.0	198.8	0.43	1800	254
b50	184	694.1	198.7	0.43	1800	234
b50	184	690.7	198.7	0.43	1800	266
b50	184	692.0	198.8	0.43	1800	254
b50	184	691.8	198.9	0.43	1800	256
b50	184	695.0	198.8	0.43	1800	225
b50	184	733.4	198.8	0.43	1850	234
b50	184	733.7	198.8	0.43	1850	231
b50	184	733.5	198.8	0.43	1850	233
b50	184	734.3	198.9	0.43	1850	225
b50	184	733.3	198.9	0.43	1850	235
b50	184	732.1	198.9	0.43	1850	246
b50	184	776.2	198.9	0.43	1900	207

CRC Technical Report SSR-1945/SO-45930

b50	184	776.1	198.9	0.43	1900	208
b50	184	773.2	198.9	0.43	1900	239
b50	184	774.9	198.9	0.43	1900	222
b50	184	774.9	198.9	0.43	1900	222
b50	184	712.2	199.2	0.5	1700	280
b50	184	716.9	199.1	0.5	1700	244
b50	184	717.8	199.1	0.5	1700	237
b50	184	716.9	199.1	0.5	1700	244
b50	184	715.8	199.1	0.5	1700	253
b50	184	728.1	198.9	0.5	1725	317
b50	184	727.1	198.9	0.5	1725	323
b50	184	725.0	198.7	0.5	1725	336
b50	184	726.6	198.8	0.5	1725	326
b50	184	727.9	198.8	0.5	1725	318
b50	184	742.2	198.8	0.5	1750	362
b50	184	746.5	199	0.5	1750	337
b50	184	747.5	199	0.5	1750	331
b50	184	746.0	199	0.5	1750	340
b50	184	746.5	199	0.5	1750	337
b50	184	790.7	199	0.5	1800	338
b50	184	795.4	199	0.5	1800	309
b50	184	793.9	199	0.5	1800	319
b50	184	790.7	199	0.5	1800	338
b50	184	795.3	199	0.5	1800	310
b50	184	809.2	199	0.51	1800	321
b50	184	818.9	199.1	0.52	1800	355
b50	184	818.4	199	0.52	1800	358
b50	184	823.9	199	0.52	1800	327
b50	184	819.5	199.1	0.52	1800	352
b50	184	824.9	199.1	0.52	1800	321
b50	184	873.0	199	0.55	1800	315
b50	184	868.9	199	0.55	1800	338
b50	184	872.7	199	0.55	1800	317
b50	184	860.0	199.1	0.55	1800	383
b50	184	867.4	199	0.55	1800	346
b50	184	899.8	198.9	0.57	1800	340
b50	184	904.6	198.9	0.57	1800	314
b50	184	900.9	199	0.57	1800	334
b50	184	899.5	198.8	0.57	1800	341
b50	184	896.8	198.8	0.57	1800	355
b50	184	915.0	198.8	0.58	1800	342
b50	184	919.2	198.8	0.58	1800	320

CRC Technical Report SSR-1945/SO-45930

b50	184	917.5	198.8	0.58	1800	329	
b50	184	913.1	198.7	0.58	1800	351	
b50	184	916.9	198.8	0.58	1800	332	
b50	184	916.3	198.8	0.58	1800	335	
b50	184	946.0	198.7	0.6	1800	343	
b50	184	943.7	198.7	0.6	1800	354	
b50	184	950.6	198.7	0.6	1800	320	
b50	184	943.9	198.7	0.6	1800	353	
b50	184	946.8	198.7	0.6	1800	339	
b50	184	1023.2	198.9	0.65	1800	347	
b50	184	1024.9	198.9	0.65	1800	339	
b50	184	1022.5	198.9	0.65	1800	350	
b50	184	1016.8	198.9	0.65	1800	374	
b50	184	1019.9	198.9	0.65	1800	361	
b50	184	1092.8	199.1	0.62	1900	339	
b50	184	1096.5	199.1	0.62	1900	321	
b50	184	1094.0	199.1	0.62	1900	333	
b50	184	1088.9	199.1	0.62	1900	357	
b50	184	1086.9	199.1	0.62	1900	366	
b50	184	1179.2	199.1	0.6	2000	317	
b50	184	1176.8	199.1	0.6	2000	329	
b50	184	1171.5	199.1	0.6	2000	355	
b50	184	1177.6	199.1	0.6	2000	325	
b50	184	1174.8	199.1	0.6	2000	339	
b50	184	1330.7	199.1	0.68	2000	337	
b50	184	1336.6	199.1	0.68	2000	310	
b50	184	1339.3	199.1	0.68	2000	297	
b50	184	1334.3	199.1	0.68	2000	321	
b50	184	1329.8	199.1	0.68	2000	341	
b50	184	1446.6	199.2	0.75	2000	409	
b50	184	1867.4	199.1	0.75	2250	328	
b50	184	2314.9	199.1	0.75	2500	319	
b50	184	3045.7	199.1	1	2500	421	
b50	184	3804.3	199.1	1.25	2500	422	
b50	184	3805.8	198.9	1.25	2500	419	
b50	184	4525.4	198.8	1.5	2500	478	
b50	184	8425.2	198.5	1.935	3000	549	
b50	184	8400.2	198.5	1.935	3000	572	
b50	184	8336.4	198.6	1.935	3000	627	
b50	184	8429.4	198.8	1.935	3000	545	
b50	184	8383.4	198.7	1.935	3000	587	
b51	198.1	15.9	11.72	199.1	0.02	1000	588

CRC Technical Report SSR-1945/SO-45930

b52	198.3	13.6		199.1	0.01	1000	384
b52	198.3	13.7		199.1	0.01	1000	340
b52	198.3	13.4		199.1	0.01	1000	421
b52	198.3	13.6		199.1	0.01	1000	366
b52	198.3	13.6		199.1	0.01	1000	384
b52	198.3	15.2		199.1	0.015	1000	461
b52	198.3	14.7		199.2	0.015	1000	526
b52	198.3	14.4		199.2	0.015	1000	565
b52	198.3	14.7		199.2	0.015	1000	527
b52	198.3	14.6		199.2	0.015	1000	547
b52	198.3	15.9		199.3	0.02	1000	584
b52	198.3	16.0		199.3	0.02	1000	574
b52	198.3	15.6		199.3	0.02	1000	614
b52	198.3	15.5		199.3	0.02	1000	620
b52	198.3	16.3		199.3	0.02	1000	555
b52	198.3	16.3		199.3	0.025	1000	663
b52	198.3	19.9		199.3	0.02	1250	708
b52	198.3	31.6	9.4	199.3	0.025	1500	684
b53	198.8	13.9		199.5	0.02	900	597
b53	198.8	16.0		199.4	0.02	1000	575
b53	198.8	16.1		199.5	0.02	1000	573
b53	198.8	16.1		199.4	0.02	1000	566
b53	198.8	16.0		199.5	0.02	1000	582
b53	198.8	15.7		199.4	0.02	1000	603
<u>b53</u>	<u>198.8</u>	18.1		199.3	<u>0.02</u>	<u>1100</u>	<u>581</u>
b53	198.8	17.8		199.5	0.02	1100	608
b53	198.8	17.1		199.5	0.02	1100	657
b53	198.8	17.6		199.4	0.02	1100	621
b53	198.8	17.4		199.4	0.02	1100	632
b53	198.8	19.8		199.4	0.02	1200	631
b53	198.8	19.4		199.4	0.02	1200	656
b53	198.8	19.5		199.3	0.02	1200	647
b53	198.8	19.6		199.3	0.02	1200	642
b53	198.8	19.7		199.3	0.02	1200	638
b53	198.8	23.0	10.94	199.3	0.02	1300	566
b54 lfl	186	16540.4		198.7	1.935	4200	744
b54 lfl	186	16547.6		198.5	1.935	4200	739
b54 lfl	186	16553.3		198.3	1.935	4200	735
b54 lfl	186	16553.3		198.2	1.935	4200	735
b54 lfl	186	16541.8		198	1.935	4200	743
b55 lfl	188.8	16503.8	0.78	198.5	1.935	4200	769
b56 lfl	190.4	9721.4		198.9	1.935	3250	724

CRC Technical Report SSR-1945/SO-45930

b56 lfl	190.4	9724.2	198.8	1.935	3250	722
b56 lfl	190.4	9724.1	198.6	1.935	3250	722
b56 lfl	190.4	9777.2	198.6	1.935	3250	683
b56 lfl	190.4	9749.0	198.5	1.935	3250	704
b56 lfl	190.4	11341.3	198.6	1.935	3500	733
b56 lfl	190.4	11328.5	198.6	1.935	3500	742
b56 lfl	190.4	11332.8	198.7	1.935	3500	739
b56 lfl	190.4	11316.9	198.7	1.935	3500	750
b56 lfl	190.4	11324.2	198.8	1.935	3500	745
b56 lfl	190.4	13106.2	198.8	1.935	3750	725
b56 lfl	190.4	13100.6	198.8	1.935	3750	729
b56 lfl	190.4	13077.8	198.7	1.935	3750	745
b56 lfl	190.4	13120.1	198.7	1.935	3750	715
b56 lfl	190.4	13038.1	198.6	1.935	3750	772
b56 lfl	190.4	14977.9	198.7	1.935	4000	727
b56 lfl	190.4	14958.0	198.4	1.935	4000	741
b56 lfl	190.4	14984.9	198.6	1.935	4000	722
b56 lfl	190.4	14923.1	198.5	1.935	4000	765
b56 lfl	190.4	14946.5	198.7	1.935	4000	749
b56 lfl	190.4	15764.4	198.3	1.935	4100	725
b56 lfl	190.4	16176.0	198.4	1.935	4150	716
b56 lfl	190.4	16155.0	198.3	1.935	4150	731
b56 lfl	190.4	16201.4	198.5	1.935	4170	808
b56 lfl	190.4	16499.3	198.4	1.935	4200	772
b56 lfl	190.4	16903.6	0.85	198.6	1.935	4250
b56 lfl	190.4	16903.6		198.6	1.935	775
b57	188.1	198.3	198.8	0.105	1900	99
b58	185.8	539.6	199.6	0.35	1750	181
b58	185.8	539.2	199.6	0.35	1750	186
b58	185.8	541.2	199.6	0.35	1750	153
b58	185.8	541.7	199.6	0.35	1750	143
b58	185.8	541.8	199.5	0.35	1750	141
b58	185.8	539.2	199.5	0.35	1750	186
b58	185.8	706.9	199.6	0.35	2000	119
b58	185.8	706.8	199.6	0.35	2000	122
b58	185.8	707.0	199.5	0.35	2000	117
b58	185.8	705.6	199.6	0.35	2000	147
b58	185.8	704.7	199.6	0.35	2000	164
b58	185.8	743.5	199.7	0.35	2050	87
b58	185.8	742.6	199.6	0.35	2050	111
b58	185.8	743.6	199.5	0.35	2050	84
b58	185.8	743.6	199.6	0.35	2050	83
b58	185.8	743.5	199.6	0.35	2050	86

CRC Technical Report SSR-1945/SO-45930

b58	185.8	778.8	199.6	0.35	2100	116
b58	185.8	780.7	199.6	0.35	2100	46
b58	185.8	780.3	199.5	0.35	2100	68
b58	185.8	780.9	199.5	0.35	2100	33
b58	185.8	781.0	199.4	0.35	2100	27
b58	185.8	808.5	199.4	0.4	2000	66
b58	185.8	808.1	199.5	0.4	2000	79
b58	185.8	807.5	199.5	0.4	2000	95
b58	185.8	807.9	199.3	0.4	2000	85
b58	185.8	807.1	199.3	0.4	2000	105
b58	185.8	852.0	199.5	0.5	1850	228
b58	185.8	851.1	199.5	0.5	1850	236
b58	185.8	853.2	199.4	0.5	1850	217
b58	185.8	852.9	199.4	0.5	1850	220
b58	185.8	852.7	199.3	0.5	1850	221
b58	185.8	900.3	199.3	0.5	1900	215
b58	185.8	900.1	199.3	0.5	1900	217
b58	185.8	901.9	199.3	0.5	1900	199
b58	185.8	897.4	199.2	0.5	1900	240
b58	185.8	899.1	199.3	0.5	1900	226
b58	185.8	1000.9	199.3	0.5	2000	184
b58	185.8	1001.6	199.3	0.5	2000	176
b58	185.8	1001.1	199.3	0.5	2000	182
b58	185.8	1001.9	199.4	0.5	2000	173
b58	185.8	1001.6	199.3	0.5	2000	176
b58	185.8	1106.0	199.3	0.5	2100	153
b58	185.8	1110.1	199.3	0.5	2100	84
b58	185.8	1106.7	199.3	0.5	2100	144
b58	185.8	1108.5	199.2	0.5	2100	115
b58	185.8	1109.3	199.2	0.5	2100	101
b58	185.8	1271.5	199	0.5	2250	117
b58	185.8	1272.5	199	0.5	2250	98
b58	185.8	1271.5	199	0.5	2250	117
b58	185.8	1273.2	198.9	0.5	2250	83
b58	185.8	1272.2	198.9	0.5	2250	104
b58	185.8	1568.5	198.9	0.5	2500	114
b58	185.8	1568.9	198.9	0.5	2500	107
b58	185.8	1568.7	198.9	0.5	2500	112
b58	185.8	1570.8	198.9	0.5	2500	64
b58	185.8	1569.1	199	0.5	2500	104
b58	185.8	1871.6	199.2	0.6	2500	206
b58	185.8	1870.4	199.1	0.6	2500	215

CRC Technical Report SSR-1945/SO-45930

b58	185.8	1974.8	199.1	0.75	2300	221
b58	185.8	2330.9	199	0.75	2500	243
b58	185.8	3076.5	198.8	1	2500	340
b58	185.8	3824.4	199	1.25	2500	382
b58	185.8	4544.9	199	1.5	2500	450
b58	185.8	6908.6	198.8	1.935	2720	517
b58	185.8	6884.1	198.9	1.935	2720	541
b58	185.8	6885.1	198.9	1.935	2720	540
b58	185.8	6895.5	198.8	1.935	2720	530
b58	185.8	7075.3	198.8	1.935	2750	509
b59	196.3	19.3	198.8	0.005	2000	0
b59	196.3	19.3	198.8	0.005	2000	0
b59	196.3	19.3	198.8	0.005	2000	0
b59	196.3	19.3	198.8	0.005	2000	0
b59	196.3	19.3	198.8	0.005	2000	0
b59	196.3	21.9	198.8	0.005	2250	0
b59	196.3	22.0	199	0.005	2250	0
b59	196.3	22.0	198.9	0.005	2250	0
b59	196.3	22.0	199	0.005	2250	0
b59	196.3	22.0	199	0.005	2250	0
b59	196.3	24.9	199	0.005	2500	0
b59	196.3	24.9	198.9	0.005	2500	0
b59	196.3	24.9	198.9	0.005	2500	0
b59	196.3	24.9	198.9	0.005	2500	0
b59	196.3	24.9	11.13	198.9	0.005	2500
b60	189.5	209.2	198.7	0.1	2000	49
b60	189.5	209.1	198.6	0.1	2000	65
b60	189.5	208.9	198.5	0.1	2000	81
b60	189.5	208.7	198.6	0.1	2000	103
b60	189.5	209.0	198.6	0.1	2000	76
b60	189.5	262.3	198.5	0.1	2250	38
b60	189.5	262.4	198.5	0.1	2250	0
b60	189.5	262.3	198.6	0.1	2250	39
b60	189.5	262.2	198.6	0.1	2250	64
b60	189.5	262.2	198.7	0.1	2250	69
b60	189.5	321.7	198.8	0.1	2500	41
b60	189.5	321.8	198.8	0.1	2500	0
b60	189.5	321.6	198.7	0.1	2500	59
b60	189.5	321.3	198.7	0.1	2500	97
b60	189.5	321.8	198.8	0.1	2500	0
b60	189.5	340.0	198.7	0.15	2100	22
b60	189.5	340.0	198.6	0.15	2100	24

CRC Technical Report SSR-1945/SO-45930

b60	189.5	339.9	198.6	0.15	2100	46
b60	189.5	339.8	198.6	0.15	2100	59
b60	189.5	340.0	198.8	0.15	2100	0
b60	189.5	372.2	198.8	0.15	2200	23
b60	189.5	372.3	198.8	0.15	2200	0
b60	189.5	372.3	198.8	0.15	2200	0
b60	189.5	372.3	199	0.15	2200	0
b60	189.5	372.3	199	0.15	2200	0
b60	189.5	372.3	199	0.15	2200	0
b60	189.5	406.0	199	0.15	2300	22
b60	189.5	406.1	199	0.15	2300	6
b60	189.5	406.0	198.8	0.15	2300	0
b60	189.5	406.0	198.9	0.15	2300	5
b60	189.5	406.0	198.8	0.15	2300	0
b60	189.5	441.3	7.64	198.8	0.15	2400
b61	189.2	441.3	198.8	0.15	2400	0
b61	189.2	441.3	198.5	0.15	2400	0
b61	189.2	441.3	198.6	0.15	2400	0
b61	189.2	441.3	198.5	0.15	2400	0
b61	189.2	441.3	198.6	0.15	2400	0
b61	189.2	459.4	198.4	0.15	2450	0
b61	189.2	459.4	198.5	0.15	2450	0
b61	189.2	459.4	198.5	0.15	2450	0
b61	189.2	459.4	198.5	0.15	2450	0
b61	189.2	459.5	198.7	0.15	2450	0
b61	189.2	478.0	198.7	0.15	2500	0
b61	189.2	478.0	198.7	0.15	2500	0
b61	189.2	478.0	198.7	0.15	2500	0
b61	189.2	478.0	198.7	0.15	2500	0
b61	189.2	484.0	198.8	0.25	1950	68
b61	189.2	483.9	198.8	0.25	1950	73
b61	189.2	484.1	198.9	0.25	1950	65
b61	189.2	484.2	199	0.25	1950	60
b61	189.2	483.8	199	0.25	1950	79
b61	189.2	508.2	198.9	0.25	2000	95
b61	189.2	507.7	198.9	0.25	2000	114
b61	189.2	507.8	198.9	0.25	2000	109
b61	189.2	507.9	198.9	0.25	2000	105
b61	189.2	508.4	8.5	198.9	0.25	2000
b62	194.2	62.2	198.5	0.05	1550	534
b62	194.2	63.7	198.5	0.05	1550	476

CRC Technical Report SSR-1945/SO-45930

b62	194.2	63.3	198.5	0.05	1550	490
b62	194.2	64.1	198.5	0.05	1550	457
b62	194.2	63.5	198.5	0.05	1550	483
b62	194.2	67.9	198.5	0.05	1600	461
b62	194.2	68.2	198.4	0.05	1600	450
b62	194.2	66.9	198.4	0.05	1600	503
b62	194.2	68.4	198.5	0.05	1600	442
b62	194.2	68.4	198.5	0.05	1600	442
b62	194.2	72.3	198.7	0.05	1650	450
b62	194.2	72.5	198.7	0.05	1650	442
b62	194.2	73.6	198.7	0.05	1650	389
b62	194.2	73.1	198.7	0.05	1650	411
b62	194.2	73.0	198.8	0.05	1650	416
b62	194.2	78.3	198.8	0.05	1700	359
b62	194.2	77.9	198.6	0.05	1700	378
b62	194.2	78.0	198.6	0.05	1700	375
b62	194.2	77.1	198.6	0.05	1700	421
b62	194.2	77.9	198.7	0.05	1700	379
b62	194.2	82.5	198.6	0.05	1750	363
b62	194.2	82.5	198.7	0.05	1750	368
b62	194.2	82.5	198.7	0.05	1750	365
b62	194.2	82.8	198.7	0.05	1750	350
b62	194.2	82.7	198.7	0.05	1750	354
b62	194.2	87.4	198.7	0.05	1800	339
b62	194.2	87.5	198.7	0.05	1800	335
b62	194.2	87.2	198.7	0.05	1800	353
b62	194.2	87.7	198.7	0.05	1800	322
b62	194.2	87.6	198.5	0.05	1800	328
b62	194.2	95.4	198.3	0.07	1600	312
b62	194.2	94.5	198.3	0.07	1600	354
b62	194.2	94.0	198.3	0.07	1600	371
b62	194.2	94.6	198.4	0.07	1600	350
b62	194.2	94.3	198.4	0.07	1600	359
b62	194.2	100.5	198.3	0.07	1650	340
b62	194.2	100.7	198.3	0.07	1650	332
b62	194.2	100.8	198.3	0.07	1650	327
b62	194.2	100.5	198.5	0.07	1650	341
b62	194.2	100.6	198.8	0.07	1650	337
b62	194.2	100.7	10.18	198.8	0.07	1650
b63	194.6	64.7	198.7	0.05	1550	429
b63	194.6	64.7	198.7	0.05	1550	429
b63	194.6	62.6	36.91	198.7	0.05	1500
						345

b64	208.4	8.0	185	0.47	0	0
b65	210	5.3	150.5	0.47	0	0
b65	210	5.3	150.5	0.47	0	0
b65	210	5.3	150.4	0.47	0	0
b65	210	5.3	150.4	0.47	0	0
b65	210	5.3	150.4	0.47	0	0
b65	210	6.0	160.4	0.47	0	0
b65	210	6.1	160.6	0.47	0	0
b65	210	6.1	160.6	0.47	0	0
b65	210	6.0	160	0.47	0	0
b65	210	6.1	160.6	0.47	0	0
b65	210	6.8	170.6	0.47	0	0
b65	210	6.8	170.4	0.47	0	0
b65	210	6.8	170.4	0.47	0	0
b65	210	6.8	170.4	0.47	0	0
b65	210	7.7	180.5	0.47	0	0
b65	210	7.7	180.6	0.47	0	0
b65	210	7.7	180.6	0.47	0	0
b65	210	7.7	180.6	0.47	0	0
b65	210	8.5	190.5	0.47	0	0
b65	210	8.5	190.6	0.47	0	0
b65	210	8.5	190.6	0.47	0	0
b65	210	8.5	190.7	0.47	0	0
b65	210	8.5	190.7	0.47	0	0
b65	210	9.3	199.1	0.47	0	0
b65	210	9.3	199.2	0.47	0	0
b65	210	9.3	199.2	0.47	0	0
b65	210	9.3	199.2	0.47	0	0
b65	210	11.8	199.1	0.005	1000	0
b65	210	11.8	199.3	0.005	1000	0
b65	210	11.8	199.2	0.005	1000	0
b65	210	11.8	198.8	0.005	1000	0
b65	210	11.8	199	0.005	1000	0
b65	210	13.2	199	0.005	1250	0
b65	210	13.2	199.1	0.005	1250	0
b65	210	13.2	198.9	0.005	1250	0
b65	210	13.2	198.8	0.005	1250	0
b65	210	13.2	198.8	0.005	1250	0
b65	210	13.2	198.9	0.005	1250	0

CRC Technical Report SSR-1945/SO-45930

b65	210	13.2		199	0.005	1250	0
b65	210	13.2		199	0.005	1250	0
b65	210	14.9		199	0.005	1500	0
b65	210	14.9		198.9	0.005	1500	0
b65	210	14.9		199.1	0.005	1500	0
b65	210	14.9		199.1	0.005	1500	0
b65	210	14.9		199.1	0.005	1500	0
b65	210	17.0		199.1	0.005	1750	
b66	206.9	8.1	58.2	185.5	0	0	0
b67	190	11.8		198.9	0.005	1000	0
b67	190	20.2		198.9	0.01	1500	272
b67	190	29.6		199.1	0.02	1500	473
b67	190	39.3		199.1	0.03	1500	503
b67	190	42.6		199	0.035	1500	591
b67	190	61.5		199.1	0.05	1500	404
b67	190	60.7		199.1	0.05	1500	442
b67	190	57.7		199.1	0.035	1700	351
b67	190	63.7		199.1	0.035	1800	366
b67	190	70.4		199.1	0.035	1900	349
b67	190	77.8		199	0.035	2000	294
b67	190	85.3		198.9	0.035	2100	262
b67	190	93.0		199	0.035	2200	243
b67	190	101.2		199	0.035	2300	202
b67	190	109.4		198.8	0.035	2400	201
b67	190	118.2		198.9	0.035	2500	167
b67	190	127.3		199	0.035	2600	130
b67	190	136.7		198.9	0.035	2700	85
b67	190	146.4		198.9	0.035	2800	85
b67	190	156.4		198.8	0.035	2900	65
b67	190	166.8		198.8	0.035	3000	36
b67	190	177.4		198.8	0.035	3100	35
b67	190	165.2		199	0.05	2500	111
b67	190	178.2		199.1	0.05	2600	72
b67	190	191.5		199	0.05	2700	52
b67	190	205.3		199.1	0.05	2800	14
b67	190	297.3		199.1	0.1	2400	0
b67	190	373.8		199.1	0.1	2700	0
b67	190	459.6	32.32	199.2	0.25	1900	90
b68	190	57.9		199.8	0.035	1700	341
b68	190	60.4		199.2	0.035	1750	377
b68	190	64.9		199.3	0.035	1800	257
b68	190	67.7		199.3	0.035	1850	293

CRC Technical Report SSR-1945/SO-45930

b68	190	70.6	199.1	0.035	1900	329
b68	190	74.6	199.2	0.035	1950	274
b68	190	85.4	199.3	0.035	2100	257
b68	190	96.4	199.2	0.035	2250	290
b68	190	109.0	199.2	0.035	2400	258
b68	190	118.1	199.1	0.035	2500	189
b68	190	127.1	199.4	0.035	2600	168
b68	190	136.6	199.2	0.035	2700	123
b68	190	146.0	199.1	0.035	2800	166
b68	190	156.1	199.1	0.035	2900	149
b68	190	166.7	199.2	0.035	3000	76
b68	190	178.0	199.2	0.05	2600	112
b68	190	191.5	199.2	0.05	2700	64
b68	190	205.3	199.3	0.05	2800	58
b68	190	234.3	199.1	0.05	3000	18
b68	190	264.5	199.2	0.07	2700	0
b68	190	322.9	198.9	0.08	2800	0
b68	190	345.7	198.9	0.08	2900	0
b68	190	373.8	199	0.1	2700	0
b68	190	401.3	199.1	0.1	2800	0
b68	190	429.8	199.1	0.1	2900	0
b68	190	459.3	199.3	0.25	1900	101
b68	190	482.9	199.1	0.25	1950	116
b68	190	436.1	199.1	0.25	1850	90
b68	190	508.4	199	0.25	2000	87
b68	190	533.8	199.1	0.25	2050	82
b68	190	560.1	199.1	0.25	2100	63
b68	190	613.9	199	0.25	2200	58
b68	190	670.5	199.1	0.25	2300	28
b68	190	729.3	198.9	0.25	2400	0
b68	190	790.5	198.9	0.25	2500	0
b68	190	854.3	199	0.25	2600	0
b68	190	858.0	199	0.5	1850	167
b68	190	905.5	199	0.5	1900	159
b68	190	1003.8	199	0.5	2000	148
b68	190	1215.3	199	0.5	2200	127
b68	190	1329.2	198.9	0.5	2300	101
b68	190	1445.5	198.9	0.5	2400	124
b68	190	1568.4	198.9	0.5	2500	117
b68	190	1828.7	198.9	0.5	2700	111
b68	190	7426.2	198.7	1.935	2800	417
b68	190	8293.7	198.5	1.935	2960	446

CRC Technical Report SSR-1945/SO-45930

b69	190	229.0	199	0.1	2100	127	
b69	190	228.6	199	0.1	2100	157	
b69	190	272.6	32.62	198.8	0.1	2300	156
b70	202.3	6.8	170.7	0	0	0	
b70	202.3	6.8	170.5	0	0	0	
b70	202.3	6.8	170.4	0	0	0	
b70	202.3	6.8	170.5	0	0	0	
b70	202.3	6.8	170.4	0	0	0	
b70	202.3	7.7	180.6	0	0	0	
b70	202.3	7.7	180.7	0	0	0	
b70	202.3	7.7	180.7	0	0	0	
b70	202.3	7.7	180.8	0	0	0	
b70	202.3	7.7	180.7	0	0	0	
b70	202.3	8.5	190.3	0	0	0	
b70	202.3	8.5	190.2	0	0	0	
b70	202.3	8.5	190.5	0	0	0	
b70	202.3	8.5	190.4	0	0	0	
b70	202.3	8.5	190.5	0	0	0	
b70	202.3	9.3	199	0	0	0	
b70	202.3	9.3	199	0	0	0	
b70	202.3	9.3	199	0	0	0	
b70	202.3	9.3	199.1	0	0	0	
b70	202.3	9.3	199	0	0	0	
b70	202.3	11.8	198.9	0.005	1000	0	
b70	202.3	11.8	198.9	0.005	1000	0	
b70	202.3	11.8	199.1	0.005	1000	0	
b70	202.3	11.8	198.9	0.005	1000	0	
b70	202.3	11.8	199	0.005	1000	0	
b70	202.3	12.3	199	0.005	1100	0	
b70	202.3	12.3	199	0.005	1100	0	
b70	202.3	12.3	198.9	0.005	1100	0	
b70	202.3	12.3	198.9	0.005	1100	0	
b70	202.3	12.3	198.9	0.005	1100	0	
b70	202.3	12.9	198.9	0.005	1200	0	
b70	202.3	12.9	198.9	0.005	1200	0	
b70	202.3	12.9	198.9	0.005	1200	0	
b70	202.3	12.9	198.9	0.005	1200	0	
b70	202.3	12.9	198.9	0.005	1200	0	
b70	202.3	13.5	199.1	0.005	1300	0	
b70	202.3	13.5	199	0.005	1300	0	
b70	202.3	13.5	199.1	0.005	1300	0	
b70	202.3	13.5	199	0.005	1300	0	

CRC Technical Report SSR-1945/SO-45930

b70	202.3	13.5	199	0.005	1300	0	
b70	202.3	14.2	199.2	0.005	1400	0	
b70	202.3	14.2	199.1	0.005	1400	0	
b70	202.3	14.2	199	0.005	1400	0	
b70	202.3	14.2	199	0.005	1400	0	
b70	202.3	14.2	199.1	0.005	1400	0	
b70	202.3	14.9	198.7	0.005	1500	0	
b70	202.3	14.9	199	0.005	1500	0	
b70	202.3	14.9	198.8	0.005	1500	0	
b70	202.3	14.9	198.8	0.005	1500	0	
b70	202.3	14.9	198.7	0.005	1500	0	
b70	202.3	14.9	198.8	0.005	1500	0	
b70	202.3	15.7	198.9	0.005	1600	0	
b70	202.3	15.7	198.8	0.005	1600	0	
b70	202.3	15.7	198.8	0.005	1600	0	
b70	202.3	15.7	198.8	0.005	1600	0	
b70	202.3	15.7	198.9	0.005	1600	0	
b70	202.3	16.5	52.83	198.8	0.005	1700	0